SOIL REACTION FORCES
ON AGRICULTURAL DISC IMPLEMENTS

Volume II

by

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CONTENTS

FIGURES

K-FACTOR CHARTS

CORRECTION FACTOR CHARTS

TABLES

COMPUTER PROGRAMMES
Fig. 2.1 Kinematics of the disc.
Fig. 2.2 Resultant soil reaction forces acting on a vertical disc. (a) A thrust force $T$, plus a radial force $U$ and (b) a horizontal force $R_h$ plus a vertical force $V$. 
Fig. 2.3 General force relation and soil-force system representation on a disc (A. W. Clyde).
Fig. 3.1 Geometric parameters of the disc.
Fig. 3.2  (a) Disc interface divided into a finite number of narrow tines. (b) Disc interface with basic types of rupture boundary.
Fig. 3.3 Sphere of unit radius.
Fig. 3.4 The effect of attitude angles on the disc setting.
Fig. 3.5 Intersections of (1) horizontal soil surface plane, (2) any vertical plane and (3) disc face plane defined by the disc sphere.
Fig. 3.6 Intersections of (1) horizontal soil surface plane and (2) any vertical plane defined by the disc sphere.
Fig. 3.7 Dimensions of (1) horizontal soil plane and (2) any vertical plane defined by the disc sphere.
Fig. 3.8 Sign convention for $\theta$
Fig. 3.9 Determination of $d$ with respect to disc setting (projection in X-Z plane).

Fig. 3.10 Criteria of the disc rear face scrubbing.
Fig. 3.11 Basic and auxiliary system of co-ordinates for the disc rear face scrubbing analysis.
Fig. 3.12 Width of cut in relation to the disc setting.
Fig. 3.13 Intersections of (1) horizontal soil surface plane, (2) vertical plane in Y-Z and (3) disc face plane defined by the disc sphere.
Fig. 3.14 Disc back-ward scrubbing rake angle, rake length and depth of cut.
Fig. 4.1 (a) Mohr's circle illustrating the two planes of incipient failure; (b) Sokolovski's solution to earth pressure problem.
Fig. 4.2 Main types of slip-line fields; (a) Basic field comprising the Interface (I), Transition (T) and Rankine (R) zones. (b) Small rake angles inducing a stress discontinuity between (I) and (R). (c) Large rake angles with soil boundary wedge (W) fixed to interface. (d) Small rake angles with wedge or discontinuity for a fully rough interface.
Fig. 4.3  (a) Basic slip-line field and rupture zone.  
(b) Mohr's diagram.
Fig. 4.4 (a) The plane of discontinuity OF separates the Interface and Rankine zones. (b) The stress conditions on either side of the discontinuity.

Fig. 4.5 Mohr's diagram for calculating the orientation of the plane of discontinuity.
Fig. 4.6 Boundary wedge formation and influence of direction of motion on wedge geometry. (a) Basic slip-line field showing range of $\beta_t$ for which it is valid. (b), (c) Boundary wedges when is outside range. (d) Limit of application of analysis when $\beta_t = \left(45^\circ - \frac{1}{2} \varphi\right)$.
Fig. 4.7 The development of boundary wedge with varying rake angle for a fixed horizontal direction of translation ($\beta_0 = 0$).
Fig. 5.1 Forces acting on the soil rupture block in basic passive failure (a) Interface zone (b) Transition zone and half the passive Rankine zone.
Fig. 5.2 Co-hesive and Adhesive forces on the soil block adjacent to the disc concave working surface.
Fig. 5.3 Gravitational forces on the soil block adjacent to the disc concave working surface.
Fig. 5.4 Forces on the soil block adjacent to the disc convex (scrubbing) surface.
Fig. 5.5 Forces acting on the disc interface.
Fig. 5.6 Forces acting on rupture block with a discontinuity.
Fig. 5.7 Special case when $\varphi = 0$. (a) Estimation of $\theta^+$. (b) Minimum value of $\theta^+$. 

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In the diagram, the figure illustrates the special case when $\varphi = 0$. Figure (a) shows the estimation of $\theta^+$, while Figure (b) demonstrates the minimum value of $\theta^+$.
Fig. 5.8 Effective force calculation using method of slices.
Fig. 5.9 Calculation of the angle $\eta$. 
Fig. 5.10  Modified rupture block in the vicinity of the bearing capacity conception.
Fig. 6.1. Recording unit comprises of an Oscillograph recorder, amplifiers and an event marker regulator.
Fig. 6.2. Complete test rig.
Fig. 6.3 Dynamometer arrangements between parallel plates.
Fig. 6.4 Design of the test rig extension.
Fig. 6.5 Reaction forces on the side-way positioned dynamometers with respect to the lateral force on the disc.
Fig. 6.6 Disc angle selector.
Fig. 6.7 Disc inclination angle selector.
Fig. 6.8. Disc leg assembly.
Fig. 6.9 Circuit diagram of the event marker regulator.
Fig. 6.10 Nature of the surcharge during disc is in operation.
Fig. 6.11 Computation of Cohesion and Soil internal friction angle from Shear-Box test.
Fig. 6.12 Computation of Aohesion and Soil-Metal friction angle from Shear-Box test.
Fig. 6.13 Computation of Cohesion and Soil internal friction angle from Tri-axial test.
Fig. 6.14 Comparison between the predicted (solid line) and experimental (broken line) results.
Fig. 6.15 Comparison between the predicted (solid line) and experimental (broken line) results.
Fig. 6.16 Comparison between the predicted (solid line) and experimental (broken line) results.
Fig. 6.17 Comparison between the predicted (solid line) and Godwins (1985) experimental (broken line) results.
Fig. 6.18 Variation in Specific resistance with Disc angle

- a/R = 0.84
- R = 600mm
- Alpha = 5 deg
Fig. 6.19 Variation in Projected Width of cut with Disc angle
Fig. 7.1 Force component at interface.
Fig. 7.2 Comparison between K-values for different a/R.
Fig. 7.3 Comparison between K-values for different a/R.
Fig. 7.4 Comparison between K-values for different a/R.
Fig. 7.5 Comparison between K-values for different a/R.
Fig. 7.6 Comparison between K-values for different a/R.
Fig. 7.7 Comparison between K-values for different a/R.
Fig. 7.8 Comparison between K-values for different Depth of Cut.
Fig. 7.9 Comparison between K-values for different Depth of Cut.
Fig. 7.10 Comparison between K-values for different Depth of Cut.
Fig. 7.11 Comparison between K-values for different Depth of Cut.
Fig. 7.12 Comparison between K-values for different Depth of Cut.
Fig. 7.13 Comparison between K-values for different Depth of Cut.
Fig. 7.14 Logarithmic interpolation.
Chart 1. K-factor for Longitudinal-Gravitation Force
Chart 2. K-factor for Longitudinal Cohesive-Adhesive Force
Chart 3. K-factor for Longitudinal Surcharge Force
Chart 6. K-factor for Lateral Surcharge Force
Chart 7. K-factor for Longitudinal-Gravitation Force
Chart 8. K-factor for Longitudinal Cohesive-Adhesive Force
Chart 9. K-factor for Longitudinal Surcharge Force
Chart 15. K-factor for Longitudinal Surcharge Force
Chart 42. K-factor for Lateral Surcharge Force.

Kg.x

Alpha = 20 degree
a/R = 0.817, 0.843, 0.866
R = 650mm
Z = 100mm

K-values (Dimensionless Number)

Disc Angle, Beta (Degree)
Chart 44. K-factor for Longitudinal Cohesive-Adhesive Force.
2.50
2.25
2.00
1.75
1.50
1.25
1.00
0.75
0.50
0.25
0.00

30 35 40 45 50 55 60

Disc Angle, Beta (Degree)

K-values (Dimensionless Number)

K_{qx}

\alpha / R: 0.817, 0.843, 0.866

R: 650mm

Z: 100mm

\phi (Degree)

40

\alpha: 20 degree


Legend:
- \( \Phi_1 \) (Degree)
- \( \alpha/R \): 0.817, 0.843, 0.866
- \( R \): 650 mm
- \( Z \): 100 mm

Kfy
Alpha : 0 degree
a/R : 0.820, 0.844, 0.866
R : 700mm
Z : 100mm
Chart 60. K-factor for Lateral Surcharge Force.
Chart 64. K-factor for Lateral Gravitation Force.
Chart 73. Xi-Values for Correction Equation.
Chart 74. $\xi$-Values for Correction Equation.
Chart 75. $\xi$-Values for Correction Equation.
Chart 76. Xi-Values for Correction Equation.
Chart 77. Xi-Values for Correction Equation.
Chart 78. Xi-Values for Correction Equation.
Chart 79. $\xi$-Values for Correction Equation.
Chart 80. Xi-Values for Correction Equation.
Chart 81. Xi-Values for Correction Equation.
Chart 82. Xi-Values for Correction Equation.
Chart 83. XI-Values for Correction Equation.
Kgy
Alpha : 10 degree
R : 600mm
(0.84 (C), 0.866 (F), 0.888 (I))
R : 650mm
(0.817 (A), 0.866 (D), 0.866 (G))
R : 700mm
(0.820 (B), 0.844 (E), 0.866 (H))

Chart 84. Xi-Values for Correction Equation.
Chart 85. Xi-Values for Correction Equation.
Chart 86. \( \xi \)-Values for Correction Equation.
Chart 87. XI-Values for Correction Equation.
Chart 88. $x_1$-Values for Correction Equation.
Chart 89. Xi-Values for Correction Equation.
Chart 90. Xi-Values for Correction Equation.
Chart 91. *Xi*-Values for Correction Equation.
Chart 92. Xi-Values for Correction Equation.
Key

\[ \alpha = 15 \text{ degree} \]

\[ R = 600\text{mm} \]

(0.84 (C), 0.866 (F), 0.888 (I))

\[ R = 650\text{mm} \]

(0.817 (A), 0.866 (D), 0.866 (G))

\[ R = 700\text{mm} \]

(0.820 (B), 0.844 (E), 0.866 (H))

\( \xi \)-values (Dimensionless Number)

Soil-Soil Friction Angle \( \Phi \) (degree)

Chart 93. \( \xi \)-Values for Correction Equation.
Chart 94. Xi-Values for Correction Equation.
Chart 95. Xi-Values for Correction Equation.
Chart 96. $k_{qz}$ Values for Correction Equation.
Chart 97. $\xi$-Values for Correction Equation.
Chart 98. Xi-Values for Correction Equation.
Chart 99. Xi-Values for Correction Equation.
Chart 100. Xi-Values for Correction Equation.
Chart 101. Xi-Values for Correction Equation.
Chart 102. Xi-Values for Correction Equation.
Chart 103. Xi-Values for Correction Equation.
Chart 104. $X_i$-Values for Correction Equation.
Table 1

K-factor for Vertical Gravitation Force (Kgz)

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* K-values calculated for the depth of 100mm
Table : 2

K-factor for Vertical Cohesive-Adhesive Force (Kcz)

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* K-values calculated for the depth of 100mm
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K-factor for Vertical Surcharge Force (Kqz)

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* K-values calculated for the depth of 100mm
Table 4

K-factor for Vertical Gravitation Force (K_{gz})

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* K-values calculated for the depth of 100mm
Table: 5

K-factor for Vertical Cohesive-Adhesive Force (Kcz)

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* K-values calculated for the depth of 100mm
### Table: 6

K-factor for Vertical Surcharge Force (Kqz)

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* K-values calculated for the depth of 100mm
Table 7

K-factor for Vertical Gravitation Force (Kgz)

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* K-values calculated for the depth of 100mm
Table 8

K-factor for Vertical Cohesive-Adhesive Force (K<sub>cz</sub>)

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* K-values calculated for the depth of 100mm
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* K-values calculated for the depth of 100mm
Table: 10

K-factor for Vertical Gravitation Force (Kgz)

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* K-values calculated for the depth of 100mm
**Table 11**

K-factor for Vertical Cohesive-Adhesive Force (Kcz)

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| 10            | 0              | 0.155        | 0.134| 0.124| 0.111| 0.104| 0.109| 0.109|
|               | 5              | 0.134        | 0.124| 0.111| 0.104| 0.109| 0.199| 0.234|
|               | 10             | 0.124        | 0.111| 0.104| 0.109| 0.234| 0.225| 0.225|
|               | 15             | 0.111        | 0.104| 0.109| 0.234| 0.225| 0.225| 0.212|
|               | 20             | 0.104        | 0.109| 0.234| 0.225| 0.225| 0.212| 0.195|
|               | 25             | 0.109        | 0.234| 0.225| 0.212| 0.195| 0.195| 0.174|
|               | 30             | 0.234        | 0.225| 0.212| 0.195| 0.174| 0.174| 0.148|
|               | 35             | 0.225        | 0.212| 0.195| 0.174| 0.148| 0.243| 0.236|
|               | 40             | 0.212        | 0.195| 0.174| 0.148| 0.243| 0.236| 0.236|

| 15            | 0              | 0.155        | 0.123| 0.104| 0.083| 0.085| 0.079| 0.079|
|               | 5              | 0.123        | 0.104| 0.083| 0.085| 0.079| 0.236| 0.236|
|               | 10             | 0.104        | 0.083| 0.085| 0.079| 0.236| 0.212| 0.212|
|               | 15             | 0.083        | 0.085| 0.079| 0.236| 0.212| 0.185| 0.154|
|               | 20             | 0.085        | 0.079| 0.236| 0.212| 0.185| 0.154| 0.121|
|               | 25             | 0.079        | 0.236| 0.212| 0.185| 0.154| 0.121| 0.089|
|               | 30             | 0.236        | 0.212| 0.185| 0.154| 0.121| 0.089| 0.252|
|               | 35             | 0.212        | 0.185| 0.154| 0.121| 0.089| 0.252| 0.229|
|               | 40             | 0.185        | 0.154| 0.121| 0.089| 0.252| 0.229| 0.229|

| 20            | 0              | 0.148        | 0.107| 0.091| 0.083| 0.072| 0.072| 0.052|
|               | 5              | 0.107        | 0.091| 0.083| 0.072| 0.052| 0.230| 0.230|
|               | 10             | 0.091        | 0.083| 0.072| 0.052| 0.230| 0.197| 0.197|
|               | 15             | 0.083        | 0.072| 0.052| 0.230| 0.197| 0.197| 0.160|
|               | 20             | 0.072        | 0.052| 0.230| 0.197| 0.160| 0.121| 0.121|
|               | 25             | 0.052        | 0.230| 0.197| 0.160| 0.121| 0.081| 0.081|
|               | 30             | 0.230        | 0.197| 0.160| 0.121| 0.081| 0.050| 0.050|
|               | 35             | 0.197        | 0.160| 0.121| 0.081| 0.050| 0.251| 0.251|
|               | 40             | 0.160        | 0.121| 0.081| 0.050| 0.251| 0.217| 0.217|

* K-values calculated for the depth of 100mm
Table: 12

K-factor for Vertical Surcharge Force (Kqz)

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* K-values calculated for the depth of 100mm
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* K-values calculated for the depth of 100mm
Table: 14

K-factor for Vertical Cohesive-Adhesive Force (Kcz)

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* K-values calculated for the depth of 100mm
Table : 15

K-factor for Vertical Surcharge Force (Kqz)

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|                 | 5               | 0.643           | 0.619 | 0.593 | 0.563 | 0.534 | 0.529 | 0.628 |
|                 | 10              | 0.619           | 0.593 | 0.563 | 0.529 | 0.628 | 0.660 | 0.660 |
|                 | 15              | 0.593           | 0.563 | 0.529 | 0.628 | 0.660 | 0.660 | 0.636 |
|                 | 20              | 0.563           | 0.529 | 0.628 | 0.660 | 0.660 | 0.636 | 0.608 |
|                 | 25              | 0.529           | 0.628 | 0.660 | 0.660 | 0.636 | 0.608 | 0.576 |
|                 | 30              | 0.628           | 0.660 | 0.660 | 0.636 | 0.608 | 0.576 | 0.540 |
|                 | 35              | 0.660           | 0.660 | 0.636 | 0.608 | 0.576 | 0.540 | 0.702 |
|                 | 40              | 0.636           | 0.608 | 0.576 | 0.540 | 0.702 | 0.680 | 0.680 |

|                 | 15              | 0.692           | 0.637 | 0.573 | 0.499 | 0.444 | 0.317 | 0.317 |
|                 | 5               | 0.637           | 0.573 | 0.499 | 0.444 | 0.317 | 0.317 | 0.710 |
|                 | 10              | 0.573           | 0.499 | 0.414 | 0.317 | 0.710 | 0.654 | 0.654 |
|                 | 15              | 0.499           | 0.414 | 0.317 | 0.710 | 0.654 | 0.587 | 0.587 |
|                 | 20              | 0.414           | 0.317 | 0.710 | 0.654 | 0.587 | 0.587 | 0.511 |
|                 | 25              | 0.317           | 0.710 | 0.654 | 0.587 | 0.587 | 0.511 | 0.423 |
|                 | 30              | 0.710           | 0.654 | 0.587 | 0.511 | 0.423 | 0.323 | 0.323 |
|                 | 35              | 0.654           | 0.587 | 0.511 | 0.423 | 0.323 | 0.732 | 0.732 |
|                 | 40              | 0.587           | 0.511 | 0.423 | 0.323 | 0.732 | 0.732 | 0.673 |

|                 | 20              | 0.740           | 0.651 | 0.548 | 0.430 | 0.329 | 0.298 | 0.158 |
|                 | 5               | 0.651           | 0.548 | 0.430 | 0.329 | 0.298 | 0.158 | 0.758 |
|                 | 10              | 0.548           | 0.430 | 0.298 | 0.158 | 0.758 | 0.666 | 0.666 |
|                 | 15              | 0.430           | 0.298 | 0.158 | 0.758 | 0.666 | 0.560 | 0.439 |
|                 | 20              | 0.298           | 0.158 | 0.758 | 0.666 | 0.560 | 0.439 | 0.304 |
|                 | 25              | 0.158           | 0.758 | 0.666 | 0.560 | 0.439 | 0.304 | 0.160 |
|                 | 30              | 0.758           | 0.666 | 0.560 | 0.439 | 0.304 | 0.160 | 0.779 |
|                 | 35              | 0.666           | 0.560 | 0.439 | 0.304 | 0.160 | 0.779 | 0.685 |
|                 | 40              | 0.560           | 0.439 | 0.304 | 0.160 | 0.779 | 0.685 | 0.779 |

* K-values calculated for the depth of 100mm
Table: 16

K-factor for Vertical Gravitation Force (Kgz)

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*K-values calculated for the depth of 100mm*
Table: 17

K-factor for Vertical Cohesive-Adhesive Force (Kcz)

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|            | 15             | 0.673          | 0.639          |
|            | 20             | 0.656          | 0.737          |
|            | 25             | 0.639          | 0.723          |
|            | 30             | 0.737          | 0.691          |
|            | 35             | 0.723          | 0.673          |
|            | 40             | 0.708          | 0.653          |

| 15          | 0              | 0.765          | 0.720          |
|            | 5              | 0.720          | 0.666          |
|            | 10             | 0.666          | 0.603          |
|            | 15             | 0.603          | 0.531          |
|            | 20             | 0.531          | 0.448          |
|            | 25             | 0.448          | 0.787          |
|            | 30             | 0.787          | 0.739          |
|            | 35             | 0.739          | 0.683          |
|            | 40             | 0.683          | 0.543          |

| 20          | 0              | 0.826          | 0.747          |
|            | 5              | 0.747          | 0.654          |
|            | 10             | 0.654          | 0.546          |
|            | 15             | 0.546          | 0.423          |
|            | 20             | 0.423          | 0.285          |
|            | 25             | 0.285          | 0.848          |
|            | 30             | 0.848          | 0.670          |
|            | 35             | 0.670          | 0.558          |
|            | 40             | 0.670          | 0.432          |

* K-values calculated for the depth of 100mm
Table: 19

K-factor for Vertical Gravitation Force (Kgz)

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* K-values calculated for the depth of 100mm
### Table: 20

K-factor for Vertical Cohesive-Adhesive Force (Kcz)

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| 10           | 0           | 0.339     | 0.311 | 0.280 | 0.248 | 0.215 | 0.181 |
|              | 5           | 0.311     | 0.280 | 0.248 | 0.215 | 0.181 | 0.348 |
|              | 10          | 0.280     | 0.248 | 0.215 | 0.181 | 0.348 | 0.319 |
|              | 15          | 0.248     | 0.215 | 0.181 | 0.348 | 0.319 | 0.288 |
|              | 20          | 0.215     | 0.181 | 0.348 | 0.319 | 0.288 | 0.255 |
|              | 25          | 0.181     | 0.348 | 0.319 | 0.288 | 0.255 | 0.220 |
|              | 30          | 0.348     | 0.319 | 0.288 | 0.255 | 0.220 | 0.186 |
|              | 35          | 0.319     | 0.288 | 0.255 | 0.220 | 0.186 | 0.358 |
|              | 40          | 0.288     | 0.255 | 0.220 | 0.186 | 0.358 | 0.328 |

| 15           | 0           | 0.334     | 0.283 | 0.230 | 0.176 | 0.125 | 0.078 |
|              | 5           | 0.283     | 0.230 | 0.176 | 0.125 | 0.078 | 0.343 |
|              | 10          | 0.230     | 0.176 | 0.125 | 0.078 | 0.343 | 0.291 |
|              | 15          | 0.176     | 0.125 | 0.078 | 0.343 | 0.291 | 0.236 |
|              | 20          | 0.125     | 0.078 | 0.343 | 0.291 | 0.236 | 0.181 |
|              | 25          | 0.078     | 0.343 | 0.291 | 0.236 | 0.181 | 0.128 |
|              | 30          | 0.343     | 0.291 | 0.236 | 0.181 | 0.128 | 0.080 |
|              | 35          | 0.291     | 0.236 | 0.181 | 0.128 | 0.080 | 0.354 |
|              | 40          | 0.236     | 0.181 | 0.128 | 0.080 | 0.354 | 0.300 |

| 20           | 0           | 0.337     | 0.266 | 0.195 | 0.127 | 0.069 | 0.026 |
|              | 5           | 0.266     | 0.195 | 0.127 | 0.069 | 0.026 | 0.347 |
|              | 10          | 0.195     | 0.127 | 0.069 | 0.026 | 0.347 | 0.273 |
|              | 15          | 0.127     | 0.069 | 0.026 | 0.347 | 0.273 | 0.200 |
|              | 20          | 0.069     | 0.026 | 0.347 | 0.273 | 0.200 | 0.130 |
|              | 25          | 0.026     | 0.347 | 0.273 | 0.200 | 0.130 | 0.071 |
|              | 30          | 0.347     | 0.273 | 0.200 | 0.130 | 0.071 | 0.026 |
|              | 35          | 0.273     | 0.200 | 0.130 | 0.071 | 0.026 | 0.357 |
|              | 40          | 0.200     | 0.130 | 0.071 | 0.026 | 0.357 | 0.282 |

* K-values calculated for the depth of 100mm
Table : 21

K-factor for Vertical Surcharge Force (Kqz)

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* K-values calculated for the depth of 100mm
Table: 22

K-factor for Vertical Gravitation Force (Kgz)

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|               | 5             | 0.311 | 0.286 | 0.251 | 0.207 | 0.161 | 0.379 |
|               | 10            | 0.286 | 0.251 | 0.207 | 0.161 | 0.161 | 0.379 |
|               | 15            | 0.251 | 0.207 | 0.161 | 0.379 | 0.366 | 0.336 |
|               | 20            | 0.207 | 0.161 | 0.379 | 0.366 | 0.336 | 0.294 |
|               | 25            | 0.161 | 0.379 | 0.366 | 0.336 | 0.294 | 0.243 |
|               | 30            | 0.379 | 0.366 | 0.336 | 0.294 | 0.243 | 0.188 |
|               | 35            | 0.366 | 0.336 | 0.294 | 0.243 | 0.188 | 0.450 |
|               | 40            | 0.336 | 0.294 | 0.243 | 0.188 | 0.450 | 0.433 |

| 15            | 0             | 0.286 | 0.264 | 0.227 | 0.181 | 0.130 | 0.080 |
|               | 5             | 0.264 | 0.227 | 0.181 | 0.130 | 0.080 | 0.335 |
|               | 10            | 0.227 | 0.181 | 0.130 | 0.080 | 0.335 | 0.309 |
|               | 15            | 0.181 | 0.130 | 0.080 | 0.335 | 0.309 | 0.266 |
|               | 20            | 0.130 | 0.080 | 0.335 | 0.309 | 0.266 | 0.212 |
|               | 25            | 0.080 | 0.335 | 0.309 | 0.266 | 0.212 | 0.152 |
|               | 30            | 0.335 | 0.309 | 0.266 | 0.212 | 0.152 | 0.094 |
|               | 35            | 0.309 | 0.266 | 0.212 | 0.152 | 0.094 | 0.396 |
|               | 40            | 0.266 | 0.212 | 0.152 | 0.094 | 0.396 | 0.365 |

| 20            | 0             | 0.259 | 0.229 | 0.185 | 0.132 | 0.077 | 0.030 |
|               | 5             | 0.229 | 0.185 | 0.132 | 0.077 | 0.030 | 0.303 |
|               | 10            | 0.185 | 0.132 | 0.077 | 0.030 | 0.303 | 0.268 |
|               | 15            | 0.132 | 0.077 | 0.030 | 0.303 | 0.268 | 0.216 |
|               | 20            | 0.077 | 0.030 | 0.303 | 0.268 | 0.216 | 0.154 |
|               | 25            | 0.030 | 0.303 | 0.268 | 0.216 | 0.154 | 0.090 |
|               | 30            | 0.303 | 0.268 | 0.216 | 0.154 | 0.090 | 0.035 |
|               | 35            | 0.268 | 0.216 | 0.154 | 0.090 | 0.035 | 0.357 |
|               | 40            | 0.216 | 0.154 | 0.090 | 0.035 | 0.357 | 0.315 |

* K-values calculated for the depth of 100mm
**Table 23**

K-factor for Vertical Cohesive-Adhesive Force (Kcz)

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* K-values calculated for the depth of 100mm
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* K-values calculated for the depth of 100mm
Table: 25

K-factor for Vertical Gravitation Force (Kgz)

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* K-values calculated for the depth of 100mm
Table 26

K-factor for Vertical Cohesive-Adhesive Force (Kcz)

R = 600mm

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<th>(\alpha(°))</th>
<th>(\phi(°))</th>
<th>(\beta(°))</th>
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<td>0.606</td>
<td>0.666</td>
<td>0.733</td>
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| 10      | 0       | 0.368   | 0.340    | 0.310    | 0.278    | 0.245    | 0.211    | 0.211    |
|         | 5       | 0.340   | 0.310    | 0.278    | 0.245    | 0.211    | 0.211    | 0.211    |
|         | 10      | 0.310   | 0.278    | 0.245    | 0.211    | 0.211    | 0.211    | 0.211    |
|         | 15      | 0.278   | 0.245    | 0.211    | 0.211    | 0.211    | 0.211    | 0.211    |
|         | 20      | 0.245   | 0.211    | 0.211    | 0.211    | 0.211    | 0.211    | 0.211    |
|         | 25      | 0.211   | 0.211    | 0.211    | 0.211    | 0.211    | 0.211    | 0.211    |
|         | 30      | 0.211   | 0.211    | 0.211    | 0.211    | 0.211    | 0.211    | 0.211    |
|         | 35      | 0.211   | 0.211    | 0.211    | 0.211    | 0.211    | 0.211    | 0.211    |
|         | 40      | 0.211   | 0.211    | 0.211    | 0.211    | 0.211    | 0.211    | 0.211    |

| 15      | 0       | 0.365   | 0.313    | 0.258    | 0.203    | 0.149    | 0.099    | 0.099    |
|         | 5       | 0.313   | 0.258    | 0.203    | 0.149    | 0.099    | 0.099    | 0.099    |
|         | 10      | 0.258   | 0.203    | 0.149    | 0.099    | 0.099    | 0.099    | 0.099    |
|         | 15      | 0.203   | 0.149    | 0.099    | 0.099    | 0.099    | 0.099    | 0.099    |
|         | 20      | 0.149   | 0.099    | 0.099    | 0.099    | 0.099    | 0.099    | 0.099    |
|         | 25      | 0.099   | 0.099    | 0.099    | 0.099    | 0.099    | 0.099    | 0.099    |
|         | 30      | 0.099   | 0.099    | 0.099    | 0.099    | 0.099    | 0.099    | 0.099    |
|         | 35      | 0.099   | 0.099    | 0.099    | 0.099    | 0.099    | 0.099    | 0.099    |
|         | 40      | 0.099   | 0.099    | 0.099    | 0.099    | 0.099    | 0.099    | 0.099    |

| 20      | 0       | 0.371   | 0.297    | 0.221    | 0.150    | 0.086    | 0.036    | 0.036    |
|         | 5       | 0.297   | 0.221    | 0.150    | 0.086    | 0.036    | 0.036    | 0.036    |
|         | 10      | 0.221   | 0.150    | 0.086    | 0.036    | 0.036    | 0.036    | 0.036    |
|         | 15      | 0.150   | 0.086    | 0.036    | 0.036    | 0.036    | 0.036    | 0.036    |
|         | 20      | 0.086   | 0.036    | 0.036    | 0.036    | 0.036    | 0.036    | 0.036    |
|         | 25      | 0.036   | 0.036    | 0.036    | 0.036    | 0.036    | 0.036    | 0.036    |
|         | 30      | 0.036   | 0.036    | 0.036    | 0.036    | 0.036    | 0.036    | 0.036    |
|         | 35      | 0.036   | 0.036    | 0.036    | 0.036    | 0.036    | 0.036    | 0.036    |
|         | 40      | 0.036   | 0.036    | 0.036    | 0.036    | 0.036    | 0.036    | 0.036    |

* K-values calculated for the depth of 100mm
Table : 27

K-factor for Vertical Surcharge Force (Kqz)

<table>
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<tr>
<th>R=600mm</th>
<th>α(°)</th>
<th>φ(°)</th>
<th>β(°)</th>
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<td>45</td>
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<td>0.211</td>
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</table>

| 10      |      |      |      |      |      |      |
| 0       | 0.123 | 0.115 | 0.115 | 0.112 | 0.104 | 0.090 |
| 5       | 0.115 | 0.115 | 0.112 | 0.104 | 0.090 | 0.198 |
| 10      | 0.112 | 0.104 | 0.090 | 0.198 | 0.199 | 0.197 |
| 15      | 0.104 | 0.090 | 0.198 | 0.199 | 0.197 | 0.190 |
| 20      | 0.090 | 0.198 | 0.199 | 0.197 | 0.190 | 0.178 |
| 25      | 0.198 | 0.199 | 0.197 | 0.190 | 0.178 | 0.160 |
| 30      | 0.199 | 0.197 | 0.190 | 0.178 | 0.160 | 0.192 |
| 35      | 0.197 | 0.190 | 0.178 | 0.160 | 0.192 | 0.197 |
| 40      | 0.197 | 0.190 | 0.178 | 0.160 | 0.192 | 0.197 |

| 15      |      |      |      |      |      |      |
| 0       | 0.147 | 0.124 | 0.111 | 0.094 | 0.074 | 0.057 |
| 5       | 0.124 | 0.111 | 0.094 | 0.074 | 0.057 | 0.225 |
| 10      | 0.111 | 0.094 | 0.074 | 0.057 | 0.225 | 0.208 |
| 15      | 0.094 | 0.074 | 0.057 | 0.225 | 0.208 | 0.187 |
| 20      | 0.074 | 0.057 | 0.225 | 0.208 | 0.187 | 0.161 |
| 25      | 0.057 | 0.225 | 0.208 | 0.187 | 0.161 | 0.131 |
| 30      | 0.225 | 0.208 | 0.187 | 0.161 | 0.131 | 0.098 |
| 35      | 0.208 | 0.187 | 0.161 | 0.131 | 0.098 | 0.231 |
| 40      | 0.187 | 0.161 | 0.131 | 0.098 | 0.231 | 0.216 |

| 20      |      |      |      |      |      |      |
| 0       | 0.154 | 0.120 | 0.097 | 0.073 | 0.051 | 0.034 |
| 5       | 0.120 | 0.097 | 0.073 | 0.051 | 0.034 | 0.235 |
| 10      | 0.097 | 0.073 | 0.051 | 0.034 | 0.235 | 0.204 |
| 15      | 0.073 | 0.051 | 0.034 | 0.235 | 0.204 | 0.169 |
| 20      | 0.051 | 0.034 | 0.235 | 0.204 | 0.169 | 0.131 |
| 25      | 0.034 | 0.235 | 0.204 | 0.169 | 0.131 | 0.090 |
| 30      | 0.235 | 0.204 | 0.169 | 0.131 | 0.090 | 0.050 |
| 35      | 0.204 | 0.169 | 0.131 | 0.090 | 0.050 | 0.249 |
| 40      | 0.169 | 0.131 | 0.090 | 0.050 | 0.249 | 0.219 |

* K-values calculated for the depth of 100mm
SUBROUTINE BISECT(XL,XU,FUNC,Y,IFLAG)

Procedure for locating the root Y in interval XL,XU
Flag Values: 0=Solution Found; 1=No Solution;
2=Number of iterations exceeded

XACC=1.0E-04
FMID=FUNC(XU)
F=FUNC(XL)
IF(F*FMID.GE.0.0)THEN
  IFLAG=1
  Y=0.0
  RETURN
ENDIF
IF(F.LT.0.0)THEN
  Y=XL
  DX=XU-XL
ELSE
  Y=XU
  DX=XL-XU
ENDIF

DO 10 J=1,40
  DX=DX/2.0
  XMID=Y+DX
  FMID=FUNC(XMID)
  IF(FMID.LT.0.0) Y=XMID
  IF(ABS(DX).LT.XACC.OR.FMID.EQ.0.0)THEN
    IFLAG=0
    RETURN
  ENDIF
10 CONTINUE
IFLAG=2
RETURN
END

SUBROUTINE BRAC(FX,BL,BU,NB)

Search for 2 roots and brackets values found

DIMENSION BL(2),BU(2)
NB=0
X=0.0
INT=18
DX=361.0*ARSIN(1.0)/(90.0*FLOAT(INT))
FP=FX(X)
 *
 DO 10 I=1,INT
 X=X+DX
 FC=FX(X)
 IF(FC*FP .LT. 0.0) THEN
 NB=NB+1
 BL(NB)=X - DX
 BU(NB)=X
 END IF
 *
 FP=FC
 IF(NB .EQ. 2) RETURN
 10 CONTINUE
 RETURN
 END
 *
 ********************************************
 SUBROUTINE BRAC1(FY,BL,BU,NB)
 * Search for 2 roots and brackets values found
 *
 DIMENSION BL(2),BU(2)
 NB=0
 Y=0.0
 INT=18
 DY=361.0*AR SIN(1.0)/(90.0*FLOAT(INT))
 FP=FY(Y)
 *
 DO 10 I=1,INT
 Y=Y+DY
 FC=FY(Y)
 IF(FC*FP .LT. 0.0) THEN
 NB=NB+1
 BL(NB)=Y - DY
 BU(NB)=Y
 END IF
 *
 FP=FC
 IF(NB .EQ. 2) RETURN
 10 CONTINUE
 RETURN
 END
 *
 ********************************************
 FUNCTION FB1(T)
 COMMON /FC/XC,YC,ZC/FCC/R1,R2,D,E/FCCC/R3
 X=R1*COS(T)
 Y=R1*SIN(T)
 FB1=(X-XC) * (X-XC) + (Y-YC)*(Y-YC)+
 + (D-ZC)*(D-ZC) - R3*R3
 RETURN
 END
 *
 ********************************************
 FUNCTION FB2(T)
 COMMON /FC/XC,YC,ZC/FCC/R1,R2,D,E/FCCC/R3
 X=R2*COS(T)
 Z=R2*SIN(T)
 FB2=(X-XC) * (X-XC) + (E-YC)*(E-YC)+
 + (Z-ZC)*(Z-ZC) - R3*R3
 RETURN
FUNCTION FB3(T)
COMMON /FC/XC,YC,ZC/FCC/R1,R2,D,E/FCCC/R3
Y=COS(T)
Z=SIN(T)
FB3=XC*XC + (Y-YC)*(Y-YC)+
+ (Z-ZC)*(Z-ZC) - R3*R3
RETURN
END

SUBROUTINE SCRUB (ATHETA,XO,YO,ZO,NS,NE)
Search for co-ordinate points on the disc edge
Status: 0=Scrubbing, 1=Non scrubbing
State: 2=Point above the soil surface
3=Point below the soil surface

REAL ATHETA(40),XO(40),YO(40),ZO(40)
INTEGER NS(40),NE(40)
COMMON /FC/XC,YC,ZC/FCC/R1,R2,D,E/FCCC/R3/SCR/ALPHA,BETA,RADN

TH=ASIN((D-ZC)/R3)
DO 200 N=1,40
SPACE=2.50*RADN
THETA=TH+SPACE*FLOAT(N-1)
ATHETA(N)=THETA/RADN
X=R3*COS(THETA)*SIN(BETA)+R3*SIN(THETA)*SIN(ALPHA)*COS(BETA)
Y=R3*SIN(THETA)*SIN(ALPHA)*SIN(BETA)-R3*COS(BETA)*COS(THETA)
Z=-R3*SIN(THETA)*COS(ALPHA)
XO(N)=XC-X
IF(XO(N).LE.1.0E-04.AND.XO(N).GT.0.0) THEN
XO(N)=0.0
ELSE
ENDIF
YO(N)=YC-Y
ZO(N)=ZC-Z
IF(XO(N).LE.0.0) THEN
NS(N)=0
ELSE
NS(N)=1
ENDIF
IF(ABS(ZO(N)-D).LE.(1.0E-02).AND.ABS(ZO(N)-D).GT.0.0) THEN
ZO(N)=D
ELSE
ENDIF
IF(ZO(N).GE.D) THEN
NE(N)=3
ELSE
NE(N)=2
ENDIF
200 CONTINUE
RETURN
END

SUBROUTINE PASFOR(PG,PC,PQ,PT,AF,IFLAG,APSI,AEPS,AAMU,DELTA,
BETAX = ABETAX * RADN
PHI = APHI * RADN
DELTAX = ADELTAX * RADN

IF (PHI .GE. 1.0E-06) CDEL = ASIN (SIN (DELTAX) / SIN (PHI))
IF (PHI .LT. 1.0E-06) CDEL = ASIN (AD / C)

ACDEL = CDEL / RADN
PSI = 45.0 * RADN + PHI / 2.0
APSI = PSI / RADN
EPS = 45.0 * RADN - PHI / 2.0
AEPS = EPS / RADN

AMU = (CDEL + DELTAX) / 2.0
AAMU = AMU / RADN
THP = PSI + AMU
ATHP = THP / RADN
THN = PSI - AMU
ATHN = THN / RADN
FP = TAN (PSI)

ALPHRD = 90.0 * RADN - AMU
BETAW = AMU - EPS + ALPHAR - 90.0 * RADN
AALPRD = ALPHRD / RADN
ABETAW = BETAW / RADN
ZETA = ALPHAR + AMU
OMEGA = (ZETA - ASIN (SIN (PHI) * SIN (ZETA))) / 2.0
AOMEGA = OMEGA / RADN

IF (PHI .GE. 1.0E-06) THEN
AD = C * TAN (DELTAX) / TAN (PHI)
ELSE
RADHS = 2.5 / 3.0
AD = C * RADHS
END IF

IF (ALPHAR - ALPHRD .GT. 1.0E-06) GO TO 109
IF (OMEGA - ALPHAR .LT. 1.0E-06) GO TO 203
GO TO 204

109 IF (BETAX - BETAW .GT. 1.0E-06) GO TO 201
GO TO 202

201 DELTA = DELTAX
IFLAG = 2
ADELM = ADELTAX
KT = 1

206 ETA = ALPHAR - EPS - THN
RS = RL * SIN (THP) / COS (PHI)
\[ T = RL \sin(THN)/\cos(PHI) \]
\[ U = RS \exp(ETA \tan(PHI)) \]
\[ V = U \sin(\varepsilon) \]
\[ F = U \cos(\varepsilon) \]
\[ D_1 = V/2.0 \]
\[ D_2 = 2.0 \times V/3.0 \]
\[ D_Q = F/2.0 \]
\[ D_5 = RS \cos(PHI)/2.0 \]
\[ D_4 = 2.0 \times RS \cos(PHI)/3.0 \]

\[ F_1 = 2.0 \times C \times V \times FP \]
\[ F_2 = \Gamma \times V \times FP \times FP/2.0 \]
\[ F_1D = Q \times V \times FP \times FP \]
\[ W_1 = F \times V \times \Gamma/2.0 \]
\[ AM = -3.0 \times \tan(PHI) \]
\[ \beta_01 = \varepsilon + \eta \]
\[ AMW_1 = \Gamma \times U \times U/(3.0 \times (AM \times AM + 1.0)) \]
\[ AMW_2 = \exp(AM \times \eta) \times (AM \cos(\beta_01) + \sin(\beta_01)) \]
\[ AMW = AMW_1 \times AMW_2 \]

\[ IF (\text{PHI.LT.1.0E-06}) \text{ GO TO 600} \]
\[ AMC = C \times (U - RS/RS)/2.0 \text{ TAN(PHI)} \]

600

601

202

\[ THF = 180.0 \times \text{RADN} - (\text{ALPHAR} - \text{BETAX}) \]
\[ KT = 3 \]
\[ THN = (\text{ALPHAR} - \text{BETAX}) + PHI - 90.0 \times \text{RADN} \]
\[ RH03 = PHI + 2.0 \times (\text{ALPHAR} - \text{BETAX}) \]
\[ \text{ANG} = \sin(PHI) \times \cos(RH03)/(\sin(PHI) \times \sin(RH03) - 1.0) \]
\[ \text{DELTAM} = \text{ATAN} (\text{ANG}) \]
\[ \text{ADELM} = \text{DELTAM} / \text{RADN} \]
\[ \text{DELR} = \text{DELTAM} / \text{DELTAX} \]

\[ \delta = \text{DELTAM} \]
\[ \text{IFLAG} = 3 \]

Rupture Surface with a Boundary Wedge *Type 3*
GO TO 206

* Rupture Surface with a Discontinuity *Type 2*

203 RH04=180.0*RADN-ALPHAR+OMEGA-THP
IFLAG=0
KT=2
T=RL*SIN(ALPHAR-OMEGA)/SIN(RH04)
U=RL*SIN(THP)/SIN(RH04)
V=U*SIN(OMEGA)
F=U*COS(OMEGA)

W3=GAMMA*(F*V+RL*T*SIN(THP))/2.0
A2=C*T
AF=C*RL
QF=Q*F
RH05=(THP-PHI-PHI)
RH06=(THP-PHI+ALPHAR)
ADELM=ADELTA
DELT=DELTAX

F1=2.0*C*V*FP
F2=GAMMA*V*V*FP*FP/2.0
F1D=Q*V*FP*FP
PG=(W3*SIN(RH06)-F2*COS(RH06))/SIN(RH05)
PC=(A2*COS(PHI)+AF*COS(THP-PHI)-Fl*COS(RH06))/SIN(RH05)
PQ=(QF*SIN(RH06)-F1D*COS(RH06))/SIN(RH05)
RDIST=2.0*F/Z

GO TO 205

* Rupture Surface with a Rankine Wedge *Type 4*

204 F=Z/TAN(EPS)
IFLAG=1
KT=4
G=Z/TAN(ALPHAR)-F

U=Z/SIN(EPS)
F1=2.0*C*Z*FP
F1D=Q*Z*FP*FP
F2=GAMMA*Z*Z*FP*FP/2.0
W4=GAMMA*F*Z/2.0
W5=GAMMA*G*Z/2.0
A3=U*C
Q1=F*Q
Q2=G*Q
AF=C*(Z/SIN(ALPHAR))
RHOR=PHI+2.0*(EPS-ALPHAR)
DELTAM=ATAN(SIN(PHI)*COS(RHOR)/(1.0-SIN(PHI)
+ *SIN(RHOR)))
ADELM=DELTAM/RADN
DELR=DELTAM/DELTAX
DELT=DELTAM
DELTAM=PHI*DELR
RH07=PSI-ALPHAR-DELTAM
RH08=ALPHAR+DELTAM
RH09=EPS-ALPHAR-DELTAM

PG=(W4*COS(PSI)+F2*COS(EPS))**COS(RH07)
W5*COS(RH08)
PC=(F1*COS(EPS)-A3*SIN(PHI))*COS(RH07)
+ A3*SIN(RH09)-AF*SIN(DELTAM)
PQ=(Q1*COS(PSI)+F1D*COS(EPS))*COS(RH07)
+ Q2*COS(RH08)
RDIST=(G+2.0*F)/Z

OUTPUT OF CALCULATED DATA:

205 PT=PG+PC+PQ
RETURN
END

******************************************************
MAIN PROGRAMME
******************************************************

DIMENSION DE1(2),DE2(2),BB1(2),BB2(2)
DIMENSION C1(40),C2(40),C3(40),C4(40),GG1(2),GG2(2)
REAL ATHETA(40),XO(40),YO(40),ZO(40),AL(11),AZ(11)
INTEGER NS(40),NE(40)
COMMON /FC/XC,YC,ZC//CC/R1,R2,D,E//CCC/R3
+ /ISCR/ALPHA,BETA,RADN//PSF1/ABETAX,ADELTA,APHI,RADHS
+ /PSF2/C,AD,GAMMA,Q//PSF3/ALPHAR,RL,Z
EXTERNAL FB1,FB2,FB3
RADN=ARSIN(1.0)/90.0

501 FORMAT(3F10.0)
502 FORMAT(2F10.0)
503 FORMAT(F10.0)
504 FORMAT(‘/’ ,3X,’Alpha’ ,4X,’Beta’ ,6X,’a’/’ ,2F8.2,F7.3)
505 FORMAT(‘/’ ,3X,’AlphaD’ ,2X,’BetaD’/’ ,2F8.1)
506 FORMAT(‘/’ ,5X,’No Solution in Specified Range’)
507 FORMAT(‘/’ ,23X,’C’,23X,’D’,22X,’E’,13X,’FLAGS’)
508 FORMAT(‘/’ ,6X,’D’ ,3(9X,’X’ ,6X,’Y’ ,6X,’Z’),
+ 5X,’D’,3X,’E’)
509 FORMAT(‘/’ ,F7.3,3(3X,3F7.3),3X,2I3)
510 FORMAT(‘/’ ,23X,’A’,22X,’B’,13X,’FLAGS’)
511 FORMAT(‘/’ ,6X,’E’,2(9X,’X’,6X,’Y’,6X,’Z’),
+ 5X,’B’,6X,’R’,4X,’ALPHAR’,4X,’Z’,4X,’L’)
512 FORMAT(‘/’ ,F7.3,2(3X,3F7.3),3X,13X,2F5.3)
513 FORMAT(‘/’ ,3X,’Scrubbing’)
514 FORMAT(‘/’ ,3X,’P’,10X,’PX’,8X,’PY’,8X,’PZ’,7X,’LAMDAR’,
+ 4X,’GAMAR’,4X,’DELTAR’)
515 FORMAT(F10.3,6(F10.3))
516 FORMAT(‘/’ ,7X,’C’,5X,’PHI’/’ ,F8.2,F8.1/
+ ’/’ ,7X,’Z’,3X,’ALPHAR’,4X,’BETA’/’ ,F8.2,2F8.1/
+ ’/’ ,7X,’Q’,3X,’GAMMA’/’ ,2F8.2/
+ ’/’ ,7X,’AD’,3X,’DELTA’/’ ,F8.2,F8.1)
517 FORMAT(‘/’ ,5X,’PSI’,5X,’EPS’,6X,’MU’/’ ,3F8.1/
+ ’/’ ,5X,’DEL’,5X,’TH’,5X,’TH’/’ ,3F8.1/’ )
518 FORMAT(‘/’ ,’BASIC RUPTURE SURFACE’)
519 FORMAT(‘/’ ,’BOUNDARY WEDGE MOB. FRICT.’, ’/’,
+ F8.1,’ BETA LIM. =’ ,F8.1)
520 FORMAT(‘/’ ,’BASIC DISCONTINUITY’/
+ ’/’ ,’OMEGA’= ,F6.2,’ ALPHD’= ,F6.2)
521 FORMAT(‘/’ ,’RANKINE DISCONTINUITY’)
522 FORMAT(‘/’ ,7X,’P*G’,7X,’P*C’,7X,’P*Q’,8X,’P’/’ ,4F10.3)
523 FORMAT(‘/’ ,4X,’PCX’,5X,’PCY’,5X,’PCZ’,5X,’PGX’,5X,’PGY’,
+ 5X,’PGZ’,5X,’PQX’,5X,’PQY’,5X,’PQZ’/’ ,9F8.3)
Input Data:

```
101 READ(5,501) AALPHA, A, D
102 READ(5,502) C, AD
103 READ(5,503) GAMMA
104 READ(5,503) ABETAX
105 READ(5,503) AQ
106 READ(5,503) APHI
107 READ(5,503) ADELTA
108 READ(5,503) CONST
```

Data Reduction:

```
R1=SQRT(1.0-D*D)
R3=SQRT(1.0-A*A)

DO 300 N=1,10
  SPACE=(90.0*RADN)/9.0
  BETA=SPACE*FLOAT(N-1)
  ABETA=BETA/RADN
  ALPHA=AALPHA*RADN
  PHI=APHI*RADN
  TNA=TAN(ALPHA)
  TNB=TAN(BETA)
  DALPHA=ATAN(TNA/(SQRT(1.0+TNB*TNB)))
  DBETA=ATAN(TNB/(SQRT(1.0+TNA*TNA)))
  ADA=DALPHA/RADN
  ADB=DBETA/RADN
  Q=AQ*COS(BETA)
  WRITE (6,504)AALPHA,ABETA,A
  WRITE (6,505)ADA,ADB
```

Co-ordinates of the Disc Centre and Intersection Points:

```
XC=A*COS(DBETA)*COS(ALPHA)
YC=A*COS(DALPHA)*SIN(BETA)
ZC=A*COS(DBETA)*SIN(ALPHA)
```

```
CALL BRAC(FB1,DE1,DE2,NB1)
T1=DE1(1)
T2=DE1(2)
T3=DE2(1)
T4=DE2(2)

CALL BISECT(T1,T3,FB1,QE,ME)
CALL BISECT(T2,T4,FB1,QD,MD)
XD=R1*COS(QD)
YD=R1*SIN(QD)
ZD=D

XE=R1*COS(QE)
YE=R1*SIN(QE)
ZE=D

WRITE(6,507)
WRITE(6,508)
WRITE(6,509)D, XC, YC, ZC, XD, YD, ZD,
+ XE, YE, ZE, MD, ME
WRITE(6,510)
```
* WRITE(6,511)
*
R=1.0
PCX=0.0
PCY=0.0
PCZ=0.0
PGX=0.0
PGY=0.0
PGZ=0.0
PQX=0.0
PQY=0.0
PQZ=0.0
*
DO 200 I=1,11
SPACE=ABS(YE-YD)/10.0
IF(YD.GE.YE) THEN
E=YD-SPACE*FLOAT(I-1)
ELSE
E=YE-SPACE*FLOAT(I-1)
ENDIF
*
B=ABS(YE-YD)/10.0
S=D*D+E*E
IF((1.0-S).LT.1.0E-06) THEN
WRITE(6,506)
GOTO 200
ELSE
XA=SQRT(1.0-S)
YA=E
ZA=D
ENDIF
*
R2=SQRT(1.0-E*E)
CALL BRAC(FB2,BB1,BB2,NB2)
T5=BB1(1)
T7=BB2(1)
CALL BISECT(T5,T7,FB2,QB,MB)
*
IF(I.EQ.1.0 .OR. I.EQ.11.0) THEN
XB=XA
YB YA
ZB=ZA
ELSE
XB=R2*COS(QB)
YB=E
ZB=R2*SIN(QB)
ENDIF
*
IF((ZB-D).LT.1.0E-03) THEN
AL(I)=0.0
AZ(I)=0.0
ALPHAR=0.0
END IF
IF(I.LT.2.0) THEN
GOTO 200
ELSE
AL(I)=SQRT((XA-XB)**2+(YA-YB)**2+(ZA-ZB)**2)
AZ(I)=ZB-D
ENDIF
RL=(AL(I)+AL(I-1))/2.0
\[ Z = \frac{(AZ(I) + AZ(I-1))}{2.0} \]
\[ ALPHAR = \text{ASIN}(Z/RL) \]
\[ ALR = \text{ALPHAR/RADN} \]

* WRITE (6, 512) E, XA, YA, ZA, XB, YB, ZB, MB, R2, ALR, Z, RL, Q

CALL PASFOR(PG, PC, PQ, PT, AF, IFLAG, APSI, AEPS, AAMU, DELTA, AMU, 
+ BETAX, ACDEL, ATHP, ATHN, ADELM, ABETAW, AOMEGA, AALPRD)

* WRITE (6, 517) APSI, AEPS, AAMU, ACDEL, ATHP, ATHN 
* WRITE (6, 516) C, APHI, Z, ALR, ABETAX, Q, GAMMA, AD, ADELTA 
* IF (IFLAG.EQ.2) THEN 
* WRITE (6, 518) 
* GOTO 401 
* ELSEIF (IFLAG.EQ.3) THEN 
* WRITE (6, 519) ADELM, ABETAW 
* GOTO 401 
* ELSEIF (IFLAG.EQ.0) THEN 
* WRITE (6, 520) AOMEGA, AALPRD 
* GOTO 401 
* ELSEIF (IFLAG.EQ.1) THEN 
* WRITE (6, 521) 
* ENDIF 
* 401 WRITE (6, 522) PG, PC, PQ, PT

* Force Calculation on the Concave
* Contact section:

\[ Y = E + B / 2.0 \]
\[ Y1 = E + B \]
\[ Y2 = E \]
\[ UC = Z / 2.0 \]
\[ R4 = \sqrt{(1.0 - Y**2)} \]
\[ RD = \sqrt{(R4**2 - (RL/2.0)**2)} \]
\[ RDD = \sqrt{(RD**2 + (RL/6.0)**2)} \]
\[ TH1 = 2.0 * \text{ATAN}((RL/2.0)/RD) \]
\[ TH2 = \text{ASIN}(RD/RDD) \]
\[ TH3 = 90.0 \times \text{RADN} - TH2 \]
\[ RCL = TH1 \times R4 \]
\[ PCA = PC \times \text{COS}(PHI)/\text{COS}(DELTA) \]
\[ PQR = PQ \times \text{COS}(PHI)/\text{COS}(DELTA) \]
\[ PGR = PG \times \text{COS}(PHI+TH3)/\text{COS}(DELTA) \]

* Components of Pc:

\[ PCX1 = PCA \times \text{SIN}(DELTA+ALPHAR) + AD \times RCL \times \text{COS}(ALPHAR) \]
\[ PCZ1 = PCA \times \text{COS}(DELTA+ALPHAR) - AD \times RCL \times \text{SIN}(ALPHAR) \]
\[ PCR1 = \sqrt{PCX1**2 + PCZ1**2} \]
\[ THC = \text{ATAN}(PCZ1/PCX1) \]
\[ Y = E + B / 2.0 \]
\[ UC = Z / 2.0 \]
\[ RC = \sqrt{(1.0 - (UC+D)**2)} \]
\[ CNU = \text{ASIN}(\text{ABS}(Y/RC)) \]
\[ PCE = PCX1 \times \text{COS}(CNU) \times B \]
\[ FCXE = PCE \times \text{COS}(CNU) \]
\[ FCZE = PCZ1 \times B \]
\[ IF (Y . LE. 0.0) THEN \]
\[ PCYE = -PCE \times \text{SIN}(CNU) \]
\[ ELSE \]
\[ PCYE = PCE \times \text{SIN}(CNU) \]
\[ ENDIF \]
Components of Pg:

\[ \begin{align*} 
\text{THG} &= 90.0 \times \text{RADN-DELTA-ALPHAR} \\
\text{PGX} &= \text{PGR} \times \cos(\text{THG}) \times B \\
\text{UG} &= 2.0 \times Z / 3.0 \\
\text{RG} &= \sqrt{1.0 - (\text{UG} + D)^2} \\
\text{GNU} &= \arcsin(\text{ABS}(Y/\text{RG})) \\
\text{PGE} &= \text{PGX} \times \cos(\text{GNU}) \\
\text{PGXE} &= \text{PGE} \times \cos(\text{GNU}) \\
\text{PGZE} &= \text{PGR} \times \sin(\text{THG}) \times B \\
\text{PGYE} &= \text{PGE} \times \sin(\text{GNU}) \\
\end{align*} \]

Components of Pq:

\[ \begin{align*} 
\text{THQ} &= 90.0 \times \text{RADN-DELTA-ALPHAR} \\
\text{PQX} &= \text{PQR} \times \cos(\text{THQ}) \times B \\
\text{QNU} &= \text{CNU} \\
\text{PQE} &= \text{PQX} \times \cos(\text{QNU}) \\
\text{PQXE} &= \text{PQE} \times \cos(\text{QNU}) \\
\text{PQZE} &= \text{PQR} \times \sin(\text{THQ}) \times B \\
\text{PQYE} &= \text{PQE} \times \sin(\text{QNU}) \\
\end{align*} \]

Output calculated data:

\[ \begin{align*} 
\text{PCX} &= \text{PCX} + \text{PCXE} \\
\text{PCY} &= \text{PCY} + \text{PCYE} \\
\text{PCZ} &= \text{PCZ} + \text{PCZE} \\
\text{PGX} &= \text{PGX} + \text{PGXE} \\
\text{PGY} &= \text{PGY} + \text{PGYE} \\
\text{PGZ} &= \text{PGZ} + \text{PGZE} \\
\text{PQX} &= \text{PQX} + \text{PQXE} \\
\text{PQY} &= \text{PQY} + \text{PQYE} \\
\text{PQZ} &= \text{PQZ} + \text{PQZE} \\
\end{align*} \]

200 CONTINUE

WRITE(6, 523) PCX, PCY, PCZ, PGX, PGY, PGZ, PQX, PQY, PQZ

FPX = PCX + PGX + PQX
FPY = PCY + PGY + PQY
FPZ = PCZ + PGZ + PQZ

Scrubbing Identification:

CALL SCRUB(ATHETA, X0, Y0, Z0, NS, NE)

J = 0
DO 500 K = 1, 40
IF (NS(K) .EQ. 0 .AND. NE(K) .EQ. 3) THEN
  J = J + 1
ELSE
  GOTO 500
ENDIF
500 CONTINUE

* Q=0.0
  BFX=0.0
  BPY=0.0
  BPZ=0.0
  BPRXE=0.0
  BPRYE=0.0
  BPRZE=0.0
  IF(J.LT.2.0) THEN
    GOTO 400
  ELSE
  ENDIF

* CALL BRAC1(FB3,GG1,GG2,NB3)
  T9=GG1(1)
  T11=GG2(1)
  CALL BISECT(T9,T11,FB3,QG,MG)

XG=0.0
YG=COS(QG)
ZG=SIN(QG)

XF=0.0
YF=SQRT(1.0-D**2)
ZF=D

DO 900 M=1,5
  SPACE=ABS(YF-YG)/5.0
  B=ABS(YF-YG)/5.0
  YM=YF-SPACE*FLOAT(M)
  RM=SQRT(1.0-YM**2)
  THR1=ATAN(SQRT(RM**2-D**2)/D)
  ALRD=90.0*RADN-(180.0*RADN-THR1)/2.0
  ALRR=180.0*RADN-ALRD

* Force Calculation for the Scrubbing Contact Area (above
  the limiting value ALPWN)

CALL PASFOR(PG,PC,PQ,PT,AF,IFLAG,APSI,AEPS,AAMU,DELTA,AMU,
+         BETAX,ACDEL,ATHP,ATHN,ADELM,ABETAW,AOMEGA,AALPRD)
ALPWN=(135.0*RADN-PHI/2.0)+BETAX+AMU
  IF(ALPWN.LT.ALRR) THEN
    ALPHAR=180.0*RADN-(45.0*RADN-PHI/2.0)
    RLR=(RM-D)/SIN(ALRD)
    RL=RLR/(2.0*SIN(45.0*RADN-PHI/2.0))
    Z=RLR/(2.0*TAN(45.0*RADN-PHI/2.0))
  ENDIF

CALL PASFOR(PG,PC,PQ,PT,AF,IFLAG,APSI,AEPS,AAMU,DELTA,AMU,
+         BETAX,ACDEL,ATHP,ATHN,ADELM,ABETAW,AOMEGA,AALPRD)
WRITE(6,517) APSI,AEPS,AAMU,ACDEL,ATHP,ATHN
WRITE(6,516) C,APHI,Z,ALR,BETAX,Q,GAMMA,AD,ADELM
  IF(IFLAG.EQ.2) THEN
    GOTO 402
  ELSEIF(IFLAG.EQ.3) THEN
    WRITE (6, 519) ADELM,ABETAW
    GOTO 402
  ELSEIF(IFLAG.EQ.0) THEN

WRITE(6,520) AOMEGA,AALPRD
GOTO 402
ELSEIF (IFLAG.EQ.1) THEN
WRITE(6,521)
ENDIF
402 WRITE(6,522) PG,PC,PQ,PT

DELTA=ADELTA*RADN
AC=C*RL
PT=PG+PC
W=(RLR*Z*GAMMA)/4.0
PV=2.0*COS(45.0*RADN-PHI/2.0)*(PT+AC)-W
PR=PV/COS(Delta+ALRD)
PH=PR*COS(ALRR-90.0*RADN-DELTA)
BPCZE=-PV*B

VR=(RM-D)/2.0
BRR=SQRT(1.0-(VR+D)**2)
BCNU=ASIN(ABS(YM/BRR))
BPRXE=PH*COS(BCNU)*B
BPRYE=-PH*SIN(BCNU)*B
ELSE
ALPHAR=ALRR
RL=RLR
Z=RM-D

* Force Calculation for the Scrubbing Contact Area (below
the limiting value ALPWN) :

CALL PASFOR(PG,PC,PQ,PT,AF,IFLAG,APSI,AEPS,AAMU,DELTA,AMU,
+ BETA,BETAX,ACDEL,ATHP,ATHN,ADELM,ABETAW,AOMEGA,AALPRD)
WRITE(6,517) APSI,AEPS,AAMU,ACDEL,ATHP,ATHN
WRITE(6,516) C,APHI,Z,ALR,ABETAX,Q,GAMMA,AD,ADELTA
IF (IFLAG.EQ.2) THEN
GOTO 403
ELSEIF (IFLAG.EQ.3) THEN
WRITE(6,519) ADELM,ABETAW
GOTO 403
ELSEIF (IFLAG.EQ.0) THEN
WRITE(6,520) AOMEGA,AALPRD
GOTO 403
ELSEIF (IFLAG.EQ.1) THEN
WRITE(6,521)
ENDIF
403 WRITE(6,522) PG,PC,PQ,PT

RMD=SQRT(RM**2+(RL/6.0)**2)
TH4=ACOS(RM/RMD)
BRCL=AD*RM*TH1
BPCA=PC*COS(PHI)/COS(DELTA)
BPGR=PG*COS(PHI-BTH2)/COS(DELTA)

* Components of Pg:

BTHG=90.0*RADN-DELTA-ALPHAR
BPGX1=BPGR*COS(BTHG)*B
VG=2.0*Z/3.0
BRG=SQRT(1.0-(VG+D)**2)
BGNU=ASIN(ABS(YM/BRG))
BPGE = BPGX1 * COS(BGNU)
BPGE = BPGE * COS(BGNU)
BPGZE = BPGR * SIN(BTHG) * B
BPGYE = -BPGE * SIN(BGNU)

Components of Pc:

BPCX1 = BPCA * SIN(DELTA + ALPHAR) + BRCL * COS(ALPHAR)
BPCZ1 = BPCA * COS(DELTA + ALPHAR) - BRCL * SIN(ALPHAR)
BPCR1 = SQRT(BPCX1 ** 2 + BPCZ1 ** 2)
BTHC = ATAN(BPCZ1 / BPCX1)

VC = Z / 2.0
BRC = SQRT(1.0 - (VC + D) ** 2)
BCNU = ASIN(ABS(YM / BRC))
BPCE = BPCX1 * COS(BCNU) * B
BPCXE = BPCE * COS(BCNU)
BPCZE = BPCZ1 * B
BPCYE = -BPCE * SIN(BCNU)

ENDIF

Output calculated data:

WRITE(6, 523) BPCXE, BPCYE, BPCZE, BPGXE, BPGYE, BPGZE
BPX = BPX + BPCXE + BPGXE + BPRXE
BPY = BPY + BPCYE + BPGYE + BPRYE
BPZ = BPZ + BPCZE + BPGZE + BPRZE

900 CONTINUE

FINAL OUTPUT CALCULATED DATA:

400 PX = (FPX + BPX) * CONST
PY = (FPY + BPY) * CONST
PZ = (FPZ + BPZ) * CONST
P = SQRT((PX ** 2) + (PY ** 2) + (PZ ** 2))
ALAMDR = ACOS(ABS(PX / P))
BLAMDR = ALAMDR / RADN
AGMAR = ACOS(ABS(PY / P))
GAMAR = AGMAR / RADN
ADELTR = ACOS(ABS(PZ / P))
DELTAR = ADELTR / RADN

WRITE(6, 514)
WRITE(6, 515) P, PX, PY, PZ, BLAMDR, GAMAR, DELTAR

300 CONTINUE
110 STOP
END
SUBROUTINE BISECT(XL,XU,FUNC,Y,IFLAG)
    Procedure for locating the root Y in int XL,XU
    Flag Values: 0=Solution Found; 1=No Solution;
    2=Number of iterations exceeded

    XACC=1.0E-04
    FMID=FUNC(XU)
    F=FUNC(XL)
    IF(F*FMID.GE.0.0)THEN
        IFLAG=1
        Y=0.0
        RETURN
    ENDIF
    IF(F.LT.0.0)THEN
        Y=XL
        DX=XU-XL
    ELSE
        Y=XU
        DX=XL-XU
    ENDIF

    DO 10 J=1,40
        DX=DX/2.0
        XMID=Y+DX
        FMID=FUNC(XMID)
        IF(FMID.LT.0.0) Y=XMIN
        IF(ABS(DX).LT.XACC.OR.FMID.EQ.0.0)THEN
            IFLAG=0
            RETURN
        ENDIF
    10 CONTINUE
    IFLAG=2
    RETURN
END

SUBROUTINE BRAC(FX,BL,BU,NB)
    Search for 2 roots and brackets values found

    DIMENSION BL(2),BU(2)
    NB=0
    X=0.0
    INT=18
    DX=361.0*ARSIN(1.0)/(90.0*FLOAT(INT))
FP=FX(X)
DO 10 I=1,INT
  X=X+DX
  FC=FX(X)
  IF(FC*FP.LT.0.0) THEN
    NB=NB+1
    BL(NB)=X - DX
    BU(NB)=X
  END IF
FP=FC
IF(NB.EQ.2) RETURN
10 CONTINUE
RETURN
END

FUNCTION FB1(T)
COMMON /FC/XC,YC,ZC/FCC/R1,R2,D,E/FCCC/R3
X=R1*COS(T)
Y=R1*SIN(T)
FB1=(X-XC) * (X-XC) + (Y-YC) * (Y-YC) +
    (D-ZC) * (D-ZC) - R3*R3
RETURN
END

FUNCTION FB2(T)
COMMON /FC/XC,YC,ZC/FCC/R1,R2,D,E/FCCC/R3
X=R2*COS(T)
Z=R2*SIN(T)
FB2=(X-XC) * (X-XC) + (E-YC) * (E-YC) +
    (Z-ZC) * (Z-ZC) - R3*R3
RETURN
END

SUBROUTINE SCRUB(ATHETA,XO,YO,ZO,NS,NE)
* Search for co-ordinates of points of the disc edge,
* status and state. Status: O=Scrubbing, l=Non scrubbing
* State: 2=Point above the soil level
* 3=Point below the soil level
*
REAL ATHETA(40),X0(40),Y0(40),Z0(40)
INTEGER NS(40),NE(40)
COMMON /FC/XC,YC,ZC/FCC/R1,R2,D,E/FCCC/R3/SCR/ALPHA,BETA,RADN
TH=ASIN((D-ZC)/R3)
DO 200 N=1,40
  SPACE=2.50*RADN
  THETA=TH+SPACE*FLOAT(N-1)
  ATHETA(N)=THETA/RADN

  X=R3*COS(THETA) * SIN(BETA) + R3*SIN(THETA) * SIN(ALPHA) * COS(BETA)
  Y=R3*SIN(THETA) * SIN(ALPHA) * SIN(BETA) - R3*COS(BETA) * COS(THETA)
  Z=-R3*SIN(THETA) * COS(ALPHA)

  XO(N)=XC-X
  IF(XO(N).LE.1.0E-04.AND.XO(N).GT.0.0) THEN
X0(N)=0.0
ELSE
ENDIF
Y0(N)=YC-Y
Z0(N)=ZC-Z
*
IF(X0(N) .LE.0.0) THEN
NS(N)=0
ELSE
NS(N)=1
ENDIF
*
IF(ABS(Z0(N)-D) .LE.(1.0E-02) .AND.ABS(Z0(N)-D) .GT.0.0) THEN
Z0(N)=D
ELSE
ENDIF
IF(Z0(N).GE.D) THEN
NE(N)=3
ELSE
NE(N)=2
ENDIF
200 CONTINUE
RETURN
END
*************************************************************************
SUBROUTINE PASFOR(PG,PC,PQ,PT,AF,IFLAG,APSI,AEPS,AAMU,DELTA,+ ACDDEL,ATHP,ATHN,ADELM,ABETAW,AOMEGA,AALPRD)
COMMON /SCR/ALPHA,BETA,RADN/PSFI/ABETAX,ADELTA,APHI,RADHS + /PSF2/C,AD,GAMMA,Q/PSF3/ALPHAR,RL,Z
*
Data Reduction
*
BETAX=ABETAX*RADN
PHI=APHI*RADN
DELTAX=ADELTA*RADN
*
IF(PHI.GE.1.OE-06) CDEL=ASIN(SIN(DELTAX)/SIN(PHI))
IF(PHI.LT.1.OE-06) CDEL=ASIN(AD/C)
ACDEL=CDEL/RADN
PSI=45.0*RADN+PHI/2.0
APSI=PSI/RADN
EPS=45.0*RADN-PHI/2.0
AEPS=EPS/RADN
AMU=(CDEL + DELTAX)/2.0
AAMU=AMU/RADN
THP=PSI+AMU
ATHP=THP/RADN
THN=PSI-AMU
ATHN=THN/RADN
FP=TAN (PSI)
*
Limits and Discont. Angles
*
ALPHRD=90.0*RADN-AMU
BETAW=AMU-EPS+ALPHAR-90.0*RADN
AALPRD=ALPHRD/RADN
ABETAW=BETAW/RADN
ZETA=ALPHAR+AMU
OMEGA=(ZETA-ASIN(SIN(PHI)*SIN(ZETA)))/2.0
AOMEGA=OMEGA/RADN

* Constrained Adhesion Requirement *

IF (PHI.GE.1.0E-6) THEN
AD=C*TAN(DELTAX)/TAN(PHI)
ELSE
RADHS=2.5/3.0
AD=C*RADHS
END IF

* Rupture Block Type Identification *

IF (ALPHAR-ALPHRD.GT.1.0E-06) GO TO 109
IF (OMEGA-ALPHAR.LT.1.0E-06) GO TO 203
GO TO 204
109 IF (BETAX-BETAW.GT.1.0E-06) GO TO 201
GO TO 202

* Basic Rupture Surface * Type 1 *

201 DELTA=DELTAX
IFLAG=2
ADELM=ADELTA
KT=1
206 ETA=ALPHAR-EPS-THN
RS=RL*SIN(THP)/COS(PHI)
T=RL*SIN(THN)/COS(PHI)
U=RS*EXP(ETA*TAN(PHI))
V=U*SIN(EPS)
F=U*COS(EPS)

D1=V/2.0
D2=2.0*V/3.0
DW=2.0*F/3.0
DQ=F/2.0
D5=RS*COS(PHI)/2.0
D4=2.0*RS*COS(PHI)/3.0

F1=2.0*C*V*FP
F2=Gamma*V*V*FP*FP/2.0
F1D=Q*V*FP*FP
W1=F*V*GAMMA/2.0
AM=-3.0*TAN(PHI)
RHO1=EPS+ETA
AMW1=Gamma*U*U*U/(3.0*(AM*AM+1.0))
AMW2=EXP(AM*ETA)*(AM*COS(RHO1)+SIN(RHO1))
+ -AM*COS(EPS)-SIN(EPS)
AMW=AMW1*AMW2
IF (PHI.LT.1.0E-06) GO TO 600
AMC=C*(U*U-WS*RS)/(2.0*TAN(PHI))
GO TO 601
600 AMC=C*RS*RS*ETA
601 QF=Q*F
F4=(F2*D2+W1*DW+AMW)/D4
F5C=(F1*D1+AMC)/D5
F5Q=(F1D*D1+QF*DQ)/D5

W2=GAMMA*RL*T*SIN(THP)/2.0
A2=C*T
AF=C*RL
RHO2=THP-PHI-PHI
RHOW=THP+ALPHAR-PHI

PG=(W2*SIN(RHOW) + F4*COS(PHI))/SIN(RHO2)
PC=(AF*COS(THP-PHI) + (F5C+A2)*COS(PHI))/SIN(RHO2)
PQ=F5Q*COS(PHI)/SIN(RHO2)
RDIST=2.0*F/Z
GO TO 205

* * Rupture Surface with a Boundary Wedge *Type 3*

THP=180.0*RADN-(ALPHAR-BETAX)
KT=3
THN=(ALPHAR-BETAX)+PHI-90.0*RADN
RH03=PHI+2.0*(ALPHAR-BETAX)
ANG=SIN(PHI)*COS(RH03)/(SIN(PHI)*SIN(RH03)-1.0)
DELTAM=ATAN(ANG)
ADELM=DELTAM/RADN

DELTA=DELTAM
IFLAG=3
GO TO 206

* * Rupture Surface with a Discontinuity *Type 2*

RHO4=180.0*RADN-ALPHAR+OMEGA-THP
IFLAG=0
KT=2
T=RL*SIN(ALPHAR-OMEGA)/SIN(RH04)
U=RL*SIN(THP)/SIN(RH04)
V=U*SIN(OMEGA)
F=U*COS(OMEGA)
W3=GAMMA*(F*V+RL*T*SIN(THP))/2.0
A2=C*T
AF=C*RL
QF=Q*F
RHO5=(THP-PHI-PHI)
RHO6=(THP-PHI+ALPHAR)
ADELM=ADELTA
DELTA=DELTAX

F1=2.0*C*V*FP
F2=GAMMA*V*V*FP*FP/2.0
F1D=Q*V*FP*FP
PG=(W3*SIN(RHO6)-F2*COS(RHO6))/SIN(RHO5)
PC=(A2*COS(PHI)+AF*COS(THP-PHI)-F1*COS(RHO6))/SIN(RHO5)
PQ=(QF*SIN(RHO6)-F1D*COS(RHO6))/SIN(RHO5)
RDIST=2.0*F/Z

GO TO 205

* * Rupture Surface with a Rankine Wedge *Type 4*

F=Z/TAN(EPS)
IFLAG=1
KT=4
G=Z/TAN(ALPHAR)-F
U = Z / SIN(EPS)
F1 = 2.0 * C * Z * FP
F1D = Q * Z * FP * FP
F2 = GAMMA * Z * FP * FP / 2.0
W4 = GAMMA * F * Z / 2.0
W5 = GAMMA * G * Z / 2.0
A3 = U * C
Q1 = F * Q
Q2 = G * Q
AF = C * (Z / SIN(ALPHAR))
RHOR = PHI + 2.0 * (EPS - ALPHAR)
DELTAM = ATAN(SIN(PHI) * COS(RHOR) / (1.0 - SIN(PHI) + *SIN(RHOR)))
ADELM = DELTAM / RADN
DELTA = DELTAM
DELTAM = PHI
RH07 = PSI - ALPHAR - PHI
RH08 = ALPHAR + PHI
RH09 = EPS - ALPHAR - PHI
PG = (W4 * COS(PSI) + F2 * COS(EPS)) * COS(RH07) + W5 * COS(RH08)
PC = (F1 * COS(EPS) - A3 * SIN(PHI)) * COS(RH07) + A3 * SIN(RH09) - AF * SIN(PHI)
PQ = (Q1 * COS(PSI) + F1D * COS(EPS)) * COS(RH07) + Q2 * COS(RH08)
RDIST = (G + 2.0 * F) / Z

OUTPUT OF CALCULATED DATA:
205 PT = PG + PC + PQ
RETURN
END

* MAIN PROGRAMME *

DIMENSION DE1(2), DE2(2), BB1(2), BB2(2)
DIMENSION C1(40), C2(40), C3(40), C4(40)
REAL ATHETA(40), XO(40), YO(40), ZO(40), AL(11), AZ(11)
INTEGER NS(40), NE(40)
COMMON /FC/XC, YC, 2C/FCC/R1, R2, D, E/FCCC/R3 + /SCR/ALPHA, BETA, RADN/PSF1/ABETAX, ADELTAM, APHI, RADNS + /PSF2/C, AD, GAMMA, Q/PSF3/ALPHAR, RL, Z
EXTERNAL FB1, FB2
RADN = ARSIN(1.0) / 90.0

501 FORMAT(3F10.0)
502 FORMAT(2F10.0)
503 FORMAT(F10.0)
504 FORMAT(/' ', '3X,' Alpha', '4X,' a', '5X,' d', '5X,' z', + 5X,' Q'/' ',F8.2, F4F7.3)
505 FORMAT(/' ', '3X,' AlphaD', '2X,' BetaD'/' ', 2F8.1)
506 FORMAT(/' ', 5X,' No Solution in Specified Range')
507 FORMAT(/' ', '23X,' C', '23X,' D', '22X,' E', '13X,' FLAGS')
508 FORMAT(/' ', 6X,' D', '3(9X,' X', '6X,' Y', '6X,' Z'), + 5X,' D', '3X,' E')
509 FORMAT(/' ', 'F7.3, 3(3X, 'F7.3, 3X, 2I3)
510 FORMAT(/' ', '23X,' A', '22X,' B', '13X,' FLAGS')
511 FORMAT(/' ', 6X,' E', '2(9X,' X', '6X,' Y', '6X,' Z'),
* 5X,'B',6X,'R2',4X,'ALPHAR',4X,'Z',4X,'L')
512 FORMAT( ' ',F7.3,2(3X,3F7.3),3X,I3,2X,5F7.3)
513 FORMAT( ' ',3X,'Scrubbing')
514 FORMAT( ' ',3X,'P',10X,'PX',8X,'PY',8X,'PZ',7X,'LAMDA',
+ 4X,'GAMA',4X,'DELTAR')
515 FORMAT(F10.3,6(F10.3))
516 FORMAT( ' ',7X,'C',5X,'PHI',',',F8.2,F8.1/
+ ' ',7X,'Z',3X,'ALPHAR',4X,'BETA',',',F8.2,2F8.1/
+ ' ',7X,'Q',3X,'GAMMA',',',2F8.2/
+ ' ',7X,'AD',3X,'DELTA',',',F8.2,F8.1)
517 FORMAT( ' ',5X,'PSI',5X,'EPS',6X,'MU',',',3F8.1/
+ ' ',5X,'TH+',5X,'TH-',',3F8.1/)
518 FORMAT( ' ',7X,'P*G',7X,'p*C',7X,'P*Q',7X,'P'
+ ' ',5X,'PCX',5X,'PCY',5X,'PCZ',5X,'PGX',5X,'PGY',
+ 5X,'PGZ',5X,'PQX',5X,'PQY',5X,'PQZ',9F8.3)
519 FORMAT( ' ',7X,'Kgx',4X,'Kcy',4X,'Kqy',4X,'Kcz',4X,'Kqz')
* 526 FORMAT(F7.1,10F7.3)

Input Data :

101 READ (5,501) AALPHA,A,D
102 READ (5,503) C
103 READ (5,503) GAMMA
104 READ (5,503) ABETAX
105 READ (5,503) Q
106 READ (5,503) APHI
107 READ (5,503) ADELTA
108 READ (5,503) CZ
109 READ (5,503) RSP

Data Reduction :

R1=SQRT(1.0-D*D)
R3=SQRT(1.0-A*A)
WRITE(6,504) AALPHA, A, D, CZ, Q
WRITE(6,524) APHI, ADELTA, C, GAMMA
WRITE(6,525)

DO 300 N=8,13
SPACE=(90.0*RADN)/18.0
BETA=SPACE*FLOAT(N-1)
ALPHA=AALPHA*RADN
PHI=APHI*RADN
TNA=TAN(ALPHA)
TNA=TAN(BETA)
DALPHA=ATAN(TNA/(SQRT(1.0+TNB*TNB)))
DBETA=ATAN(TNB/(SQRT(1.0+TNA*TNA)))
A=DALPHA/RADN
ADB=DBETA/RADN
WRITE(6,504) AALPHA, ABETA, A
WRITE(6,505) ADA, ADB
R9 = (D/COS(ALPHA)) - A*TAN(ALPHA)
W = 2.0 * (SQRT(R3^2 - R9^2)) * COS(BETA) * RSP

Co-ordinates of the Disc Centre and Intersection Points:

XC = A*COS(DBETA)*COS(ALPHA)
YC = A*COS(DALPHA)*SIN(BETA)
ZC = A*COS(DBETA)*SIN(ALPHA)

CALL BRAC(FB1, DE1, DE2, NB1)
T1 = DE1(1)
T2 = DE1(2)
T3 = DE2(1)
T4 = DE2(2)

CALL BISECT(T1, T3, FB1, QE, ME)
CALL BISECT(T2, T4, FB1, QD, MD)
XD = R1*COS(QD)
YD = R1*SIN(QD)
ZD = D

XE = R1*COS(QE)
YE = R1*SIN(QE)
ZE = D

WRITE(6, 507)
WRITE(6, 508)
WRITE(6, 509) D, XC, YC, ZC, XD, YD, ZD,
+ XE, YE, ZE, MD, ME
WRITE(6, 510)
WRITE(6, 511)

R = 1.0
PCX = 0.0
PCY = 0.0
PCZ = 0.0
PGX = 0.0
PGY = 0.0
PGZ = 0.0
PQX = 0.0
PQY = 0.0
PQZ = 0.0

DO 200 I = 1, 11
SPACE = ABS(YE - YD)/10.0
IF(YD.GE.YE) THEN
E = YD - SPACE*FLOAT(I-1)
ELSE
E = YE - SPACE*FLOAT(I-1)
ENDIF

B = ABS(YE - YD)/10.0
S = D*D + E*E
IF((1.0 - S).LT.1.0E-06)THEN
WRITE(6, 506)
GOTO 200
ELSE

99
XA = SQRT(1.0 - S)
YA = E
ZA = D
ENDIF

R2 = SQRT(1.0 - E*E)
CALL BRAC(FB2, BB1, BB2, NB2)
T5 = BB1(1)
T7 = BB2(1)
CALL BISECT(T5, T7, FB2, QB, MB)

IF (I.EQ.1.0.OR.I.EQ.11.0) THEN
XB = XA
YB = YA
ZB = ZA
ELSE
XB = R2*COS(QB)
YB = E
ZB = R2*SIN(QB)
ENDIF

IF ((ZB - D) .LT. 1.0E-03) THEN
AL(I) = 0.0
AZ(I) = 0.0
ALPHAR = 0.0
ENDIF

IF (I.LT.2.0) THEN
GOTO 200
ELSE
AL(I) = SQRT((XA-XB)**2 + (YA-YB)**2 + (ZA-ZB)**2)
AZ(I) = ZB-D
ENDIF

RL = (AL(I) + AL(I-1))/2.0
Z = (AZ(I) + AZ(I-1))/2.0
ALPHAR = ASIN(Z/RL)
ALR = ALPHAR/RADN

WRITE (6,512) E, XA, YA, ZA, XB, YB, ZB, MB, R2, ALR, Z, RL, Q

CALL PASFOR(PG, PC, PQ, PT, AF, IFLAG, APSI, AEPS, AAMU, DELTA, +
ACDEL, ATHP, ATHN, ADEL, ABETAW, AOMEGA, AALPRD)

WRITE (6,517) APSI, AEPS, AAMU, ACDEL, ATHP, ATHN
WRITE (6,516) C, APHI, Z, ALR, ABETAX, Q, GAMMA, AD, ADELTA
IF (IFLAG.EQ.2) THEN
WRITE (6,518)
GOTO 401
ELSEIF (IFLAG.EQ.3) THEN
WRITE (6,519) ADEL, ABETAW
GOTO 401
ELSEIF (IFLAG.EQ.0) THEN
WRITE (6,520) AOMEGA, AALPRD
GOTO 401
ELSEIF (IFLAG.EQ.1) THEN
WRITE (6,521)
ENDIF
401 WRITE (6,522) PG, PC, PQ, PT

* Force Calculation on the Concave Contact Section:
\[ Y = E + B / 2.0 \]
\[ Y_1 = E + B \]
\[ Y_2 = E \]
\[ UC = Z / 2.0 \]
\[ R4 = \sqrt{1.0 - Y^2} \]
\[ RD = \sqrt{R4^2 - (RL/2.0)^2} \]
\[ RDD = \sqrt{RD^2 + (RL/6.0)^2} \]
\[ TH_1 = 2.0 \cdot \text{ATAN}((RL/2.0)/RD) \]
\[ TH_2 = \text{ASIN}(RD/RDD) \]
\[ TH_3 = 90.0 \cdot \text{RADN} - TH_2 \]
\[ RCL = TH_1 \cdot R4 \]
\[ PCA = PC \cdot \text{COS}(\Phi)/\text{COS}(\Delta) \]
\[ PQR = PQ \cdot \text{COS}(\Phi)/\text{COS}(\Delta) \]
\[ PGR = PG \cdot \text{COS}(\Phi + TH_3)/\text{COS}(\Delta) \]

Components of \( P_c \):

\[ PCX_1 = PCA \cdot \text{SIN}(\Delta + \text{ALPHAR}) + AD \cdot RCL \cdot \text{COS}(\text{ALPHAR}) \]
\[ PCZ_1 = PCA \cdot \text{COS}(\Delta + \text{ALPHAR}) - AD \cdot RCL \cdot \text{SIN}(\text{ALPHAR}) \]
\[ PCR_1 = \sqrt{PCX_1^2 + PCZ_1^2} \]
\[ THC = \text{ATAN}(PCZ_1/PCX_1) \]

Components of \( P_g \):

\[ THG = 90.0 \cdot \text{RADN} - \Delta - \text{ALPHAR} \]
\[ PGX_1 = PGR \cdot \text{COS}(THG) \cdot B \]
\[ PGZ_1 = PGR \cdot \text{SIN}(THG) \cdot B \]
\[ UG = 2.0 \cdot Z / 3.0 \]
\[ RG = \sqrt{1.0 - (UG + D)^2} \]
\[ GNU = \text{ASIN}(ABS(Y/RG)) \]
\[ PQE = PGX_1 \cdot \text{COS}(GNU) \]
\[ PGXE = PQE \cdot \text{COS}(GNU) \]

Components of \( P_q \):

\[ THQ = 90.0 \cdot \text{RADN} - \Delta - \text{ALPHAR} \]
\[ PQX_1 = PQR \cdot \text{COS}(THQ) \cdot B \]
\[ PQZ_1 = PQR \cdot \text{SIN}(THQ) \cdot B \]
\[ GNU = CNU \]
\[ PQE = PQX_1 \cdot \text{COS}(GNU) \]
\[ \text{PQXE} = \text{PQE} \cdot \cos(\text{QNU}) \]

\begin{verbatim}
* IF(Y.LE.0.0) THEN
PQYE=-PQE*SIN(\text{QNU})
ELSE
PQYE=PQE*SIN(\text{QNU})
ENDIF
*
* Output calculated data:
PCX=PCX+PCXE
PCY=PCY+PCYE
PCZ=PCZ+PCZE
PGX=PGX+PGXE
PGY=PGY+PGYE
PGZ=PGZ+PGZE
PQX=PQX+PQXE
PQY=PQY+PQYE
PQZ=PQZ+PQZE
200 CONTINUE
* WRITE(6,523)PCX,PCY,PCZ,PGX,PGY,PGZ,PQX,PQY,PQZ
FPX=PCX+PGX+PQX
FPY=PCY+PGY+PQY
FPZ=PCZ+PGZ+PQZ
*
* Scrubbing Identification:
*
CALL SCRUB(\text{ATHETA},X0,Y0,Z0,\text{NS},\text{NE})
DO 500 K=1,40
IF(NS(K) .EQ.0.AND.NE(K) .EQ.3) THEN
WRITE(6,513)
GO TO 110
ELSE
GOTO 500
ENDIF
500 CONTINUE
*
* Final output calculated data:
*
400 PX=FPX
PY=FPY
PZ=FPZ
P=SQRT((\text{PX}**2)+(\text{PY}**2)+(\text{PZ}**2))
ALAMDR=ACOS(ABS(PX/P))
BLAMDR=ALAMDR/RADN
AGAMAR=ACOS(ABS(PY/P))
GAMAR=AGAMAR/RADN
ADELTR=ACOS(ABS(PZ/P))
DELTAR=ADELTR/RADN
*
* K-factor Determination:
*
AKGX=(PGX*RSP/W)/(\text{GAMMA}*(CZ**2))
AKCX=(PCX*RSP/W)/(\text{C}*[CZ])
AKQX=(PQX*RSP/W)/(\text{Q}*[CZ])
AKGY=(PGY*RSP/W)/(\text{GAMMA}*(CZ**2))
AKCY=(PCY*RSP/W)/(\text{C}*[CZ])
AKQY=(PQY*RSP/W)/(\text{Q}*[CZ])
AKGZ=(PGZ*RSP/W)/(\text{GAMMA}*(CZ**2))
AKCZ=(PCZ*RSP/W)/(\text{C}*[CZ])
AKQZ=(PQZ*RSP/W)/(\text{Q}*[CZ])
\end{verbatim}
* WRITE(6,514)
* WRITE(6,515) P, PX, PY, PZ, BLAMDR, GAMAR, DELTAR
WRITE(6,526) ABETA, RSP, AKGX, AKCX, AKQX, AKGY, AKCY, AKQY, AKGZ, AKCZ
*
300 CONTINUE
110 STOP
END
**PROGRAMME : P3**

* **********************************************
SUBROUTINE EXPFIT(A,B,C,ESQ, N,X,Y, IFLAG,ITER)
* This algorithm will fit a curve defined by the equation y = a*exp(b*x) + c to specified sets of x and y. Flag other than zero implies set number of iterations have been exceeded.
* Ref; CACM No. 275
*

DIMENSION X(N), Y(N)
IFLAG=0
EPS=0.001
LMAX=40

* Computation of initial estimate :

B=2.0*Aalog((Y(N) - Y(N-1))*(X(2) - X(1)))/
   + ((Y(2) - Y(1))*(X(N) - X(N-1)))/
   + (X(N) + X(N-1) - X(2) - X(1))
A= (Y(N) - Y(N-1))/((X(N) - X(N-1)) +
   *EXP((B*(X(N) + X(N-1)))/2.0)*B)
M=(N+1)/2
C=Y(M) - A*EXP(B*X(M))
ESQ=0.0

DO 200 I=1,N
   ESQ=ESQ + (Y(I) - C -A*EXP(B*X(I)))**2
200 CONTINUE

* Computation of corrections :

ITER=0
SAVE=0.0
DO 201 L=1,LMAX

ITER=ITER + 1
SEX1 =0.0
SEX2 =0.0
SXIEX1=0.0
SXIEX2=0.0
SX2EX2=0.0
SYI=0.0
SYIEX1=0.0
SXYEX1=0.0

DO 202 I=1,N
   EX1=EXP(B*X(I))
   EX2=EX1*EX1
   XIEX1=X(I)*EX1
   XIEX2=X(I)*EX2
   XI2EX2=X(I)*XIEX2

*
SEC1 = SEC1 + EX1
SEC2 = SEC2 + EX2
SXIEX1 = SXIEX1 + XIEX1
SXIEX2 = SXIEX2 + XIEX2
SX2EX2 = SX2EX2 + XI2EX2
SYI = SYI + Y(I)
SXIEX1 = SYIEX1 + Y(I) * EX1
SXYEX1 = SXYEX1 + Y(I) * XIEX1

202 CONTINUE

* 
D11 = SEC2
D12 = SXIEX2 * A
D13 = SEC1
D22 = SX2EX2 * A * A
D23 = SXIEX1 * A
D33 = N

* 
E1 = -SEC2 * A - SEC1 * C + SYIEX1
E2 = -SXIEX2 * A * A - SXIEX1 * C * A + SXYEX1 * A
E3 = -SEC1 * A - N * C + SYI

* 
DEL11 = D22 * D33 - D23 * D23
DEL12 = D13 * D23 - D12 * D33
DEL13 = D12 * D23 - D13 * D22
DEL22 = D11 * D33 - D13 * D13
DEL23 = D12 * D13 - D11 * D23
DEL33 = D11 * D22 - D12 * D12

DEL = D11 * DEL11 + D12 * DEL12 + D13 * DEL13

* 
U = (E1 * DEL11 + E2 * DEL12 + E3 * DEL13) / DEL
V = (E1 * DEL12 + E2 * DEL22 + E3 * DEL23) / DEL
W = (E1 * DEL13 + E2 * DEL23 + E3 * DEL33) / DEL

* 
A = A + U
B = B + V
C = C + W
ESQ = 0.0

* 
DO 203 I = 1, N
ESQ = ESQ + (Y(I) - C - A * EXP(B * X(I))) ** 2
203 CONTINUE

* 
IF (L .EQ. 1) GO TO 700
IF (ABS (SAVE - ESQ) .LT. EPS) THEN
GO TO 701
ELSE IF (L .LT. LMAX) THEN
GO TO 700
ELSE
GO TO 702
END IF

* 
700 SAVE = ESQ
201 CONTINUE
702 IFLAG = 1
701 RETURN
END

*******************************************************************************
*   Main Programme
*
DIMENSION XX(20), YY(20), YC(20), DIFF(20)
* 500 FORMAT( ' ', 13X,'a',13X,'b',13X,'c',9X,'Stat Error', + 4X,'F', 4X,'I'/3E14.4,5X,E14.4,2I5) 501 FORMAT( ' ',13X,'x',13X,'y',12X,'Yc',10X,'Diff') 502 FORMAT( ' ', ',',4E14.4) 503 FORMAT( ' ', '/ ', 'Group Index No.=',I3) 100 READ (5,'(I3)') MM 101 READ (5,'(I3)') NN IF(NN .LT. 0) THEN NROUTE=ABS(NN) GO TO (100,102), NROUTE END IF 102 STOP END