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A COMPUTER PROGRAM FOR CALCULATING AERODYNAMIC CHARACTERISTICS OF LOW ASPECT-RATIO WINGS WITH PARTIAL LEADING-EDGE SEPARATION

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<tr>
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<td>Wing span</td>
<td>m (ft)</td>
</tr>
<tr>
<td>c</td>
<td>Local chord</td>
<td>m (ft)</td>
</tr>
<tr>
<td>( C_R )</td>
<td>Root chord</td>
<td>m (ft)</td>
</tr>
<tr>
<td>M</td>
<td>Number of spanwise strips plus one</td>
<td></td>
</tr>
<tr>
<td>N</td>
<td>Number of bound elements</td>
<td></td>
</tr>
<tr>
<td>( x,y,z )</td>
<td>Wing rectangular coordinate system with ( x ) in the streamwise direction and ( y ) to the right</td>
<td>m (ft)</td>
</tr>
</tbody>
</table>

### Greek

- \( \alpha \): Angle of attack | deg

### Subscripts

- \( cp \): Control point
- \( i \): Chordwise bound element number
- \( j \): Spanwise strip number
- \( k \): Chordwise bound element number
- \( L \): Leading-edge
1. INTRODUCTION

This document describes in detail the necessary information for using a computer program to predict distributed and total aerodynamic characteristics for low aspect-ratio wings with partial leading-edge separation. This program is based on the numerical method developed in reference 1. The flow is assumed to be steady and inviscid. The wing boundary condition is formulated by the Quasi-Vortex-Lattice method. The leading-edge separated vortices are represented by discrete free vortex elements which are aligned with the local velocity vector at mid-points to satisfy the force free condition. The wake behind the trailing-edge is also force free. The flow tangency boundary condition is satisfied on the wing, including the leading- and trailing-edges.

The program is restricted to delta wings with zero thickness and no camber. It is written in Fortran language and runs on CDC 6600 Computer.
2. COMPUTER PROGRAM DESCRIPTION

2.1 PROBLEM DEFINITION

In steady symmetric flight at a high angle of attack, the flow over a thin low aspect-ratio highly sweptback wing separates along the leading-edge and the tips. In the following, only delta wings are considered. The wing can be represented by a bound vortex sheet, across which there exists a pressure difference, and the separated flow along leading-edges by force free vortex sheets, across which there is no pressure difference. In the present method, the Quasi-Vortex-Lattice method (reference 2) is used to simplify the induced velocity expressions due to the bound vortex sheet and discrete force free vortex elements for separated vortex sheets. The following boundary conditions are imposed on the flow model:

a. The flow must be tangential to the wing surface.

b. The leading-edge boundary condition and the trailing-edge Kutta condition are to be satisfied.

c. The vortex elements over the wing and wake behind the trailing-edge are force free.

This is a non-linear problem because the strengths of the wing bound vortices and free vortices, and the locations of the free vortex elements are unknown. Thus, the problem is solved by an iterative method.

2.2 PROGRAM CAPABILITIES

This computer program provides a theoretical method for determining the aerodynamic characteristics of low aspect-ratio thin delta wings without camber, with partial leading-edge separation. The following is a list of the aerodynamic characteristics the program calculates:

a. Spanwise and chordwise $\Delta C_p$ distributions
b. Spanwise distribution of sectional lift, induced-drag and pitching moment coefficients.

c. Total lift, induced-drag, pitching-moment and leading-edge thrust coefficients.

2.3 GEOMETRY DESCRIPTION

The origin of the rectangular coordinate system is at the wing apex. The wing lies in the x-y plane and the x-axis is taken along the wing center-line. The wing span is given by $b$ and the surface area $S$.

2.3.1 WING GEOMETRY

The location of bound- and trailing-vortex elements for a typical case are shown in figure 1. The x-location of bound elements is given by the cosine law and is illustrated in figure 1.

$$x_i = x_0 + \frac{c}{2} \left(1 - \cos\left(\frac{2\pi i}{2N}\right)\right), \quad (1)$$

$$i = 1, 2, \ldots N$$

where $x_0$ is the leading-edge x-coordinate, $c$ is the chord and $N$ is the number of bound elements in a chordwise direction. The spanwise location of trailing elements is given by,

$$y_j = \frac{b}{4} \left(1 - \cos\left(\frac{2\pi j}{2M}\right)\right), \quad (2)$$

$$j = 1, 2, \ldots M$$

where $b$ is the span and $M$ is the number of legs of trailing vorticity, which is one higher than the number of spanwise strips of bound elements.

The locations of control points are given by,
Figure 1. Wing geometry without leading-edge vortex system
\[ x_{cpk} = x_{kj} + \frac{c_j}{2} (1 - \cos(\frac{j\pi}{N})) \tag{3} \]

\[ k = 0, 1, 2, \ldots, N \]

\[ y_{cpj} = \frac{h}{4} (1 - \cos(\frac{j\pi}{M})) \tag{4} \]

\[ j = 1, 2, \ldots, (M - 1) \]

where \( x_{kj} \) and \( c_j \) are the leading-edge x-coordinate and chord at \( y_{cpj} \) respectively.

It has been found numerically that the aerodynamic characteristics depended on the number of spanwise strips, i.e. \( M \) of equation (2). Therefore, a parametric study has been made to find a relation between the aspect ratio and the number of spanwise strips for reasonably accurate results (Fig. 2) (Section 3 of ref. 1). It is to be noted that as the aspect ratio is decreased, the number of spanwise strips has to be increased. This is due to the fact that the spanwise variation of aerodynamic characteristics, such as pressure coefficient and thrust coefficient, is large for small aspect ratio wings. This study was performed by matching the lift coefficients obtained by using the present method to those obtained by using suction analogy (ref. 3) at one angle of attack.

2.3.2 LEADING-EDGE VORTEX SYSTEM GEOMETRY

The leading-edge vortex system is superimposed on the regular quasi-vortex-lattice grid. A typical vortex element is shown by points A through J in figure 3. These points are connected by a series of short straight segments. The initial location of these segments is shown by dashed lines and final
Figure 2. Variation of number of spanwise strips with aspect ratio
Figure 3. A typical vortex element of leading-edge vortex system
location by solid lines. These segments have the following characteristics;

a. Points A through E lie along a wing trailing vortex element.

Initially point A is one root chord away from the trailing-edge in the downstream direction and the line segments between A and D are parallel to the axis of symmetry. The line segments between points A and B are of equal length. In the final converged position these segments are aligned in the direction of the local velocity vector. The segments B-C and C-D are 0.1 \( C_R \) long. B-C is allowed to move only in the vertical direction whereas C-D is fixed in the wing plane because the flow is tangential to the trailing-edge. Segment D-E is also fixed in the wing plane.

b. Points E, F, G and H also lie in the wing plane. The location of segment E-F is ahead of the wing first bound element and is given by,

\[
x_E = x_{l_E} + \frac{c_E}{2} \left( 1 - \cos \left( \frac{\pi}{2(N + 1)} \right) \right) \quad (5.a)
\]

\[
x_F = x_{l_F} + \frac{c_F}{2} \left( 1 - \cos \left( \frac{\pi}{2(N + 1)} \right) \right) \quad (5.b)
\]

where the subscripts E and F refer to the points under consideration.

The above two equations are similar to equation (1). It is to be noted that segment E-F is located at the first bound element for a grid of \((N + 1)\) bound elements in a chordwise direction. The segments F-G and G-H are of the same length and point G lies on the leading-edge. The segment G-H is fixed in the wing plane due to the leading-edge boundary condition.
c. The initial location of point I is given by,

\[ x_I = x_F \]  
\[ y_I = y_F \]  
\[ z_I = 0.1 C_R \tan(22.5 - 0.5\alpha) \quad \text{for } \alpha \leq 15^\circ \]  
\[ \text{or } z_I = 0.1 C_R \tan \alpha \quad \text{for } \alpha > 15^\circ \]

where \( C_R \) is the root chord and \( \alpha \) is the angle of attack.

Initially point J is one root chord away from the trailing-edge. The segments between point I and J are of equal length and lie in a plane parallel to x-z plane. These segments are approximately at a height of \( 0.1 \cdot C_R \) above the wing plane. In the final converged position all the segments between points H and J are aligned in the direction of the local velocity vector.

d. The semi-infinite segments from points A to infinity and J to infinity are straight and are parallel to the undisturbed free-stream direction.

2.4 SOLUTION PROCEDURE

The basic unknowns of the problem are the bound vortex density on the wing, and the strengths and the locations of the elements of the leading-edge vortex system and the wake. The problem is nonlinear because the locations of the leading-edge vortex system and the wake are unknown a priori. Therefore, the problem is solved by the iterative process described below;
a. Prescribe the vortex lattice for the wing surface, and the initial locations of the free elements over the wing and in the wake.
b. By satisfying the wing boundary condition, obtain the bound vortex density of the wing and the strengths of free elements.
c. Calculate all the aerodynamic characteristics.
d. Calculate the forces acting on the free elements over the wing surface.
e. Adjust the free elements of the leading-edge vortex system and the wake in the local velocity vector direction.
f. Repeat steps b through e until a converged solution is obtained.

The initial locations of the free vortex elements are assumed by letting them leave the leading-edge in the undisturbed free-stream direction up-to a height of about ten percent of the root chord beyond which the elements are parallel to the wing plane. Initially, all the elements of the wake lie in the plane of the wing. In the iteration process, the force free condition is satisfied on the free elements from the root to the tip in the down-stream direction. The elements over the wing are adjusted before the elements of the wake. In the first iteration the segments over the wing are moved 100 percent according to the velocity computed at their mid-points. This movement is gradually reduced in steps of 90, 80 and 75 percent in the next three iterations, after which it remains at 75 percent (Section 2.5.2 of ref. 1). The segments in the wake are moved only 50 percent in each iteration. Thus, exact force free condition is not enforced because whenever the free elements come close to each other they induce unreasonably large velocities because viscous effects are not included in the present theory. These large velocities increase the forces on the segments and induce fluctuations in their locations.
The solution is assumed to have converged if in two consecutive iterations the difference between the total strengths of leading-edge free vortex elements is less than one percent and the absolute force acting on the free elements is in the neighborhood of a minimum. Thus, an exact force free condition is not enforced as discussed in the previous paragraph.
3. INPUT DATA FORMAT

The following is the description of input data cards for this program.

Card 1. Format (16A5)

TTL Any title identifying the case to be run. END in first three columns terminates the job.

Card 2. Format (6I5)

NCW Number of chordwise lines (limited to nine)
NSW Number of spanwise lines (one higher than number of spanwise strips of panels, limited to twenty). It depends on aspect-ratio and is determined by using figure 2.
NBRR Number of constant x-locations where $\Delta C_p$'s are to be interpolated (limited to twenty-five).
NCONTs $= 0$, Initial locations of free elements will be calculated in the program.
$= 1$, Initial locations of free elements will be read from data cards.
MITER Maximum number of iterations to be performed (usually between 10 and 15)
IPUNCH $= 0$, Coordinates of free elements will not be punched out after last iteration.
$= 1$, Coordinates of free elements will be punched out after last iteration.

Card 3. Format (6F10.5)

XXL(1) Leading-edge x-coordinate of the root chord.
XXT(1) Trailing-edge x-coordinate of the root chord.
YL(1) y-coordinate of the root chord.
XXL(2) Leading-edge x-coordinate of the tip chord.
XXT(2) Trailing-edge x-coordinate of the tip chord.
YL(2) y-coordinate of the tip chord.

Card 4. Format (7F10.5)

ALPHA Angle of attack (in degrees).
AMACH Mach number.
DELTA Length of a segment of leading-edge free vortex elements (may be taken as 0.15 CR).
DL Length of a segment of wake elements (may be taken as 0.15 CR).
XEND x-coordinate beyond which free elements of leading-edge and wake system are represented by a single element going to infinity.
CBAR Reference chord.
AREA Total reference wing area.

Card 5. Format (8F10.5)

XBRR(I), Constant x-locations where I = 1, NBRR ΔC_p's are to interpolated.

Card 6. Format (8F10.5)

CTT(I), Sectional leading-edge thrust coefficients for I = 1, (NSW-1) spanwise strips. All these values are set equal to zero for complete leading-edge separation.

*** If NCONT = 0, go back to card number 1 ***
Card 7. Format (10I2)

\[ \text{NIELM}(I), \] 
One higher than the number of segments for each leading-
I = 1, (NSW-1) edge free vortex element (numbered from root to tip).

Card 8. Format (8F10.5)

\[ XE(K), \] 
x-coordinates of the end-points of segments of \( I \)th
K = 1, NIELM(I) leading-edge free vortex element.

Card 9. Format (8F10.5)

\[ YE(K), \] 
y-coordinates of the end-points of segments of \( I \)th
K = 1, NIELM(I) leading-edge free vortex element.

Card 10. Format (8F10.5)

\[ ZE(K), \] 
z-coordinates of the end-points of segments of \( I \)th
K = 1, NIELM(I) leading-edge free vortex element.

***Cards 8 thru 10 are repeated (NSW-1) times.***

Card 11. Format (10I2)

\[ \text{NIELM}(I), \] 
One higher than the number of segments for each wake
I = 1, NSW element (numbered from root to tip).

Card 12. Format (8F10.5)

\[ XXE(K), \] 
x-coordinates of the end-points of segments of \( I \)th
K = 1, NIELM(I) trailing wake element.

Card 13. Format (8F10.5)

\[ YYE(K), \] 
y-coordinates of the end-points of segments of \( I \)th
K = 1, NIELM(I) trailing wake element.

Card 14. Format (8F10.5)

\[ ZZE(K), \] 
z-coordinates of the end-points of segments of \( I \)th
K = 1, NIELM(I) trailing wake element.

*** Cards 12 thru 14 are repeated NSW times.***
*** Go back to card number 1.***

Note: The punched data cards obtained by running this program with IPUNCH = 1, can be directly used for cards 7 thru 14 for further iterations.
4. OUTPUT DATA FORMAT

All the input data cards for each case are listed at the beginning of the output. The output data at each iteration step is as follows:

The title card (input data card number 1) is printed-out as it is inputted. The angle-of-attack (in degrees), Mach Number and iteration number are also listed. The end-point locations of the leading-edge free elements are listed next. The first row of numbers in each group are the x-coordinates, second row the y-coordinates and third row the z-coordinates. The end-point locations of the wake elements are listed in the similar manner. On the next two pages, x-y and y-z digital plots for leading-edge free-elements are made. It is to be noted that the leading-edge elements lying in the plane of the wing and along center line are not plotted. So, the elements next to the center line are represented by "l". When similar numbers are connected by straight lines, they represent the path of a free vortex element. A "+" sign represents a duplicate point. In these two plots there are (NSW-2) rows of free elements. The digital plots for wake elements are made on next two pages. The elements along center line are again not plotted. There are (NSW-1) elements.

Some of the intermediate variables are listed under following labels:

- \( X/C \): Percent chord location
- \( 2Y/B \): Percent span location
- \( \gamma_y \): Bound vortex density over the wing at the given \((X/C, 2Y/B)\)
- \( \Gamma \): Strength of leading-edge free element at the given \(2Y/B\)
- \( \Delta C_p \): The total \( \Delta C_p \) at the given \((X/C, 2Y/B)\)
The sectional properties are listed under the following labels:

I Spanwise station number (numbered from root to tip)
CLI The sectional lift coefficient
CMi The sectional pitching moment coefficient about the y-axis
CDi The sectional induced drag coefficient
CTI The sectional leading-edge thrust coefficient.

The total lift, pitching moment, induced drag and leading-edge thrust coefficients are listed after sectional properties. The spanwise pressures at constant x-locations are listed under following labels:

Y y-coordinate
2Y/B(LOCAL) Percent span location based on local span
DELTA-CP The total ΔCp at the given (x,y)

The last item listed for each iteration is the absolute force acting on leading-edge free elements.

The last page of the output is the "Summary Sheet", which is used to pick up final converged solution. It has the following format:

The title (input data card number 1) is printed again. The angle of attack (in degrees) and Mach Number are also listed. The other variables listed are,

ITERATION Iteration number
CL The total lift coefficient
CM The total pitching moment coefficient about y-axis
CD The total induced drag coefficient
CT The total leading-edge thrust coefficient
GMSUM Total sum of the strengths of leading-edge free vortex elements, except the one at the center line.
FERR	 Percent change in ONSUM values of two consecutive iterations
TFARS	 Total absolute force acting on leading-edge free elements

This program has not yet been completely automated and the converged solution is to be picked by the user, from the Summary Sheet, by using the following criteria:

The solution is assumed to have converged if in two consecutive iterations the difference between the total strengths of leading-edge free vortex elements is less than one percent and the absolute force acting on the free elements is in the neighborhood of a minimum.
5. REFERENCES


6. APPENDICES

6.1 APPENDIX A: EXAMPLE INPUT AND OUTPUT

The following is an example of delta wing of aspect-ratio 2 at an angle-of-attack of 30 degrees. The flow is assumed to be completely separated from the leading-edge and so sectional leading-edge thrust coefficients are set to zero on card number 6. Listing of input data cards is given below:

Listing of Input Data Cards

<table>
<thead>
<tr>
<th>CARD NUMBER</th>
<th>ASPECT RATIO = 2.0</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>0. 6 7 9 0 10 0</td>
</tr>
<tr>
<td>4</td>
<td>.3 0 .6 0.6 4.5 2</td>
</tr>
<tr>
<td>5</td>
<td>1 2 1 3.5 3.75 2.5</td>
</tr>
<tr>
<td>6</td>
<td>.3 0 .3 0.3 0.3 0.3</td>
</tr>
<tr>
<td>7</td>
<td>END</td>
</tr>
</tbody>
</table>

Output data is listed on the following pages. An inspection of the "Summary Sheet" suggests that the converged solution has been reached at 8th iteration.
<table>
<thead>
<tr>
<th>ASPECT RATIO = 2.0</th>
</tr>
</thead>
<tbody>
<tr>
<td>ALPHADEG. = 10.000</td>
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</table>

**LEADING EDGE ELEMENTS**

<table>
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<tr>
<th>Element</th>
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<th>y</th>
<th>z</th>
<th>x+y</th>
<th>y+z</th>
<th>z+x</th>
</tr>
</thead>
<tbody>
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<td>1</td>
<td>4.000</td>
<td>0.480</td>
<td>0.050</td>
<td>0.000</td>
<td>-0.2300</td>
<td>0.2000</td>
</tr>
<tr>
<td>2</td>
<td>0.2142</td>
<td>0.4892</td>
<td>0.000</td>
<td>0.000</td>
<td>0.000</td>
<td>0.000</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Element</th>
<th>x</th>
<th>y</th>
<th>z</th>
<th>x+y</th>
<th>y+z</th>
<th>z+x</th>
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<td>0.5309</td>
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<table>
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<th>z</th>
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<td>9.0124</td>
<td>7.7241</td>
<td>7.7341</td>
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**Total Lift Coefficient**: 1.66094
**Total Pitching Moment Coefficient**: -2.07341
**Total Drag Coefficient**: 0.95894
**Total Thrust Coefficient**: 0.00000

#### Spanwise Pressures at Constant X = 1.00000

<table>
<thead>
<tr>
<th>Y</th>
<th>2Y/B LOCAL</th>
<th>DELTA-CP</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.09903</td>
<td>0.19806</td>
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#### Spanwise Pressures at Constant X = 2.00000

<table>
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<th>DELTA-CP</th>
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<td>0.77748</td>
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#### Spanwise Pressures at Constant X = 3.00000

<table>
<thead>
<tr>
<th>Y</th>
<th>2Y/B LOCAL</th>
<th>DELTA-CP</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.09903</td>
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<td>0.37651</td>
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<tr>
<td>1.22252</td>
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#### Spanwise Pressures at Constant X = 3.50000

<table>
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<tr>
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**TOTAL ABSOLUTE FORCE ACTING ON LEADING-EDGE FREE ELEMENTS** = .42133
Similar type of output data is printed for iterations 2 through 7.
<table>
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<tr>
<td>MACH NUMBER = 0.000</td>
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<tr>
<td>ITERATION NUMBER = 8</td>
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LEADING EDGE ELEMENTS

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<th>Z</th>
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<th>Y</th>
<th>Angle</th>
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</tr>
<tr>
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<tr>
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### Sectional Properties

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**Total Lift Coefficient**: 1.45997

**Total Pitching Moment Coefficient**: -1.86231

**Total Drag Coefficient**: .84292

**Total Thrust Coefficient**: 0.00000

<table>
<thead>
<tr>
<th>Spanwise Pressures at Constant X = 1.00000</th>
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<tbody>
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<table>
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<table>
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<tr>
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<table>
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Similar type of output data is printed for iterations 9 and 10.
### SUMMARY SHEET

**ASPECT RATIO = 2.0**

**ALPHA (DEG.) = 30.000  MACH NUMBER = 0.000**

<table>
<thead>
<tr>
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<th>CI</th>
<th>GMSUM</th>
<th>PERR</th>
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</table>

ALL CASES COMPLETED
6.2 APPENDIX B: COMPUTER PROGRAM LISTING

A listing of the computer program is given on the following pages.
OVERLAY (LEVSP,0,0)
PROGRAM LEVSP(INPUT,OUTPUT,TAPE1,TAPE2,TAPE3,TAPE5,INPUT,TAPE6=OUT
INPUT,PUNCH,TAPE4,TAPE7)

AERODYNAMICS OF LOW ASPECT-RATIO WINGS WITH PARTIAL LEADING-EDGE
SEPARATION (LEADING-EDGE VORTEX SEPARATION PROGRAM)
BY — SUBHRA C. MEHRUTRA AND EDWARD LAM
UNIVERSITY OF KANSAS

THIS PROGRAM IS RESTRICTED TO DELTA AND ARROW WINGS

PROGRAM IS DIVIDED INTO FIVE OVERLAYS.
OVERLAY (1,0) READS ALL THE DATA CARDS AND SETS UP INICIAL GEOMETRY
OF THE WING AND THE FREE ELEMENTS
OVERLAY (2,0) PLAYS FREE ELEMENTS OVER THE WING AND IN THE WAKE ON
THE LINE PRINTER OUTPUT
OVERLAY (3,0) SOLVES FOR THE STRENGTHS OF WING AND LEADING-EDGE
VORTEX SYSTEM
OVERLAY (4,0) COMPUTES THE AERODYNAMIC CHARACTERISTICS
OVERLAY (5,0) COMPUTES THE NEW LOCATIONS OF THE LEADING-EDGE AND
TRAILING-EDGE VORTEXES

AS THE PROBLEM IS NONLINEAR, IT IS SOLVED BY ITERATION. ITERATION
IS PERFORMED OVER OVERLAYS (2,0) THRU (4,0) TO OBTAIN THE FINAL
CONVERGENCE SOLUTION.

THE DIMENSIONS OF THE FOLLOWING VARIABLES MUST BE CHECKED BEFORE
RUNNING THE PROGRAM.

-D- APPEARS IN BLANK COMMON OF MAIN LINE (OVERLAY(0,0))
MUST BE DIMENSIONED MAXIMUM OF THE FOLLOWING VARIABLES.
N1=228.6
N2=3*NMAX*(NSW-1)+NSW
N3=3*NSW*(NMAX+2)+NSW+1
N4=4*NCPTTL+1)**2/4+10*NWNG+10*NSW+3*NCW-6
N5=2*NWNG+25*NSW+10*NCW-14
N6=21*NWNG+14*NSW+NCW-9

-W- APPEARS IN PROGRAM LOADS (OVERLAY(4,0)
MUST BE DIMENSIONED AT LEAST (1+NG+NCW+3)*(NWNG+NCW+4))
-E- APPEARS IN PROGRAM NEWSHAP (OVERLAY(5,0))
MUST BE DIMENSIONED AT LEAST (3*NW+(NMAX+NNMAX)-3*NMAX+1)

WHERE NMAX = MAXIMUM NUMBER OF END-POINTS IN ANY ONE FREE
LEADING-EDGE VORTEX ELEMENT

NNMAX = MAXIMUM NUMBER OF END-POINTS IN ANY ONE WAKE
ELEMENT

NCW = NUMBER OF CHORDWISE LINES

NSW = NUMBER OF SPANWISE LINES (ONE HIGHER THAN
NUMBER OF SPANWISE ROWS OF PANELS)

NCPTTL = TOTAL NUMBER OF CONTROL POINTS OVER THE WING
INCLUDING THOSE AT THE LEADING-EDGE ((NCW+1)*
(NSW-1))

NWNG = TOTAL NUMBER OF CONTROL POINTS OVER THE WING
EXCLUDING THOSE AT THE LEADING-EDGE (NCW*
(NSW-1))

COMMON D(3000)
COMMON /ALL/ NSW,NSW1,NCW,NWNG,NCPTTL,MITER,IPUNCH
COMMON /ALLRA/ TTL(16),ALPHA,SGA,SINA,OSR,SMPLE,BETA,BETA2,TANPH,BSF
141,BRDCR,PRH,RCF
COMMON /XG/ ITER,L1,L2,L3,L4,L5,L6,L7,L8
CALL OVERLAY (5,HELVSP,1,0)
ITER*0
CONTINUE
ALP=ALPHA*180./PI
AMACH=AMACH1-BETA2
WRITE FREE ELEMENTS LOCATIONS
WRITE (6,100) TTL,ALP,AMACH,ITER
REWIND 4
DO 30 I=1,NSW

**---------------------------------------------**
READ (4) K,(XE(J),YE(J),ZE(J),J=1,K)
**---------------------------------------------**
WRITE (6,150) I
REWIND 7
WRITE (6,110) TL,ALP,AMACH
*IT=1*ITER+1
GM1=0.
DO 90 I=1,*IT
    J=I-1
C*******************************************************************************/
READ (7) GMSUM
READ (7) CL,CM,CD,CTT
READ (7) TFABS,TAVRG,TLNTH
C*******************************************************************************/
GM2=GMSUM
PERR=200.0*(ABS(GM1-GM2))/(GM1+GM2)
GM1=GM2
IF (1.EQ.1) GO TO 80
WRITE (6,120) J,CL,CM,CD,CTT,GMSUM,PERR,TFABS
GO TO 90
80 WRITE (6,130) J,CL,CM,CD,CTT,GMSUM,TFABS
90 CONTINUE
GO TO 10
C
C
100 FORMAT (1H1,16A5,1X,12HALPHA(DEC.),12F6.3,14H MACH NUMBER=,F6.3,14H)
1.3,19H ITERATION NUMBER=,12,1X,21HLEADING EDGE ELEMENTS=,1X,2LE1420
21H*****************************************************************************/
110 FORMAT (1H1,23X,13HSUMMARY SHEET,23X,13H*****************************************************************************/
16A5,2X,12HALPHA(DEC.)=F6.3,14H MACH NUMBER=,F6.3,2X,66H ITERA1450
2ITION CL CM CD CT GMSUM PERR TFABS,66H LE1460
3H*****************************************************************************/
120 FORMAT (17,4X,7F8.4)
130 FORMAT (17,4X,5FR.4,8X,8F8.4)
140 FORMAT (14F8.4)
150 FORMAT (5H ****,12,4H****)
160 FORMAT (10FE.5)
170 FORMAT (10I2)
180 FORMAT (1H1,14H WAKE ELEMENTS=,14H*****************************************************************************/
END
SUBROUTINE SKIPR (NT, NR)
C SKIPS NR-RECORDS OF TAPE NT
DO 10 I=1, NR
10 READ (NT)
RETURN
END
FUNCTION ARCS(X)

CALCULATES ARC-COSINE OF X

IF (X.EQ.1.0) RETURN

IF (X.EQ.(-1.0)) GOTO 10

XX=X/(SORT(1-(X*X))

ARCOS=1.5707963-ATAN(XX)

RETURN

END

C

64
SUBROUTINE DOTPRO (A,B, SUM)
CALCULATES DOT-PRODUCT OF TWO VECTORS
DIMENSION A(3), B(3)
SUM=0.
DO 10 I=1,3
10 SUM=SUM+A(I)*B(I)
RETURN
END
SUBROUTINE CRS PRD (A, B, C)
CALCULATES CROSS-PRODUCT OF TWO VECTORS
DIMENSION A(3), B(3), C(3)
C(1) = A(2)*B(3) - A(3)*B(2)
C(2) = A(3)*B(1) - A(1)*B(3)
C(3) = A(1)*B(2) - A(2)*B(1)
RETURN
END
SUBROUTINE VDTWNG (C, THETP, XX, YY, ZZ, XN, YN, XTE, YTE, CONS, CONI1, CONI3WNG
1, CONJ1, CONJ2, CONJ3, CONK1, CONK2, CONK3, CONI, CONJ, CONK, SI, NSW1, NCW, NWNG
2NG)
C EVALUATES INFLUENCE COEFFICIENTS FOR CALCULATION OF INDUCED
C VELOCITY DUE TO WING ELEMENTS
COMMON /ALLI/ NSW
COMMON /ALLRA/ XXE(30), YYE(30), ZZE(30)
COMMON /NCCT/ NCT, NCON
COMMON /XYIYZI/ XI, YI, ZI
DIMENSION THFIP(1), C(1), CONS(1), XTE(1), YTE(1), SI(1), CONI1(1) NWNG 100
1, CONI3(1), CONJ1(1), CONJ2(1), CONJ3(1), CONK1(1), CONK2(1), CONK3(1), CONI(1),
23(1), CONI(1), CONJ(1), CON(1), XN(NWNG,2), YN(NWNG,2), B(3), D(3WNG 120
3)
C DIMENSIONS OF FJ1, FJ2, FJ3-(2*NSW) ** SEE GEOM **
C DIMENSIONS OF FI2, FI3-(2*NCPTTL) ** SEE GEOM **
DIMENSION FJ1(40), FJ2(40), FJ3(40), FI2(418), FI3(418)
XI=XX
YI=YY
ZI=ZZ
NC1=NWNG+NCW
NC2=NWNG–NCW
C VELOCITY DUE TO ROUND ELEMENTS
DO 10 I=1, NSW1
DO 10 J=1, NCW
NP=(I-1)*NCW+J
CALL INFL (XN(NP,1), YN(NP,1),O., XN(NP,2), YN(NP,2), O., B)
A1=–YN(NP,1)
A2=–YN(NP,2)
CALL INFL (XN(NP,1), A1, O., XN(NP,2), A2, O., D)
CONI(NP)=CONS(I)*(R(1)-D(1))
CONI(NP)=CONS(I)*(R(2)-D(2))
CONI(NP)=CONS(I)*(R(3)-D(3))
10 C VELOCITY DUE TO TRAILING ELEMENTS ON THE WING SURFACE
DO 20 I=1, NSW1
DO 20 J=1, NCW
NP=(I-1)*NCW+J
CALL INFL2 (XN(NP,1), YN(NP,1), O., XTE(I), YN(NP,1), O., B)
FI2(NP)=R(2)
FI3(NP)=B(3)
AYN=–YN(NP,1)
NO=NCL+NP
CALL INFL2 (YN(NP,1),AYN,O,XTE(I),AYN,O,B)
FI2(NO)=B(2)
FI3(NO)=B(3)

CONTINUE
DO 30 J=1,NCW
NP1=MWG+J
NP2=NC1+NP1
NP=NC2+J
CALL INFL2 (YN(NP,2),YN(NP,2),O,XTE(NSW),YN(NP,2),O,B)
FI2(NP1)=R(2)
FI3(NP1)=R(3)
AYN=-YN(NP,7)
CALL INFL2 (YN(NP,2),AYN,O,XTE(NSW),AYN,O,B)
FI2(NP2)=R(2)
FI3(NP2)=R(3)

CONTINUE
DO 40 I=1,NSW1
NC 40 J=1,NCW
NP=(I-1)*NCW+J
I1=NP+NC1
I2=NP+NCW
I3=I1+NCW
CONJ2(NP)=CONS(I)*(FI2(I1)-FI2(NP)+FI2(I2)-FI2(I3))
CONK2(NP)=CONS(I)*(FI3(I1)-FI3(NP)+FI3(I2)-FI3(I3))

C VELOCITY DUE TO TRAILING ELEMENTS BEYOND TRAILING EDGE
C

C
RE/WIND 4
CALL SKTPR (4,NSW)
DO 40 I=2,NSW
READ (4) KK,(XXE(J),YYE(J),ZZE(J),J=1,KK)

C
FJ1(I)=0.
FJ2(I)=0.
FJ3(I)=0.
IF (I.EQ.NCT) GN TO 60
DO 50 J=2,KK
CALL INFL2 (XXE(J-1),YYE(J-1),ZZE(J-1),XXE(J),YYE(J),ZZE(J),B)
FJ1(I)=FJ1(I)+B(1)
FJ2(I)=FJ2(I)+B(2)
FJ3(I)=FJ3(I)+B(3)
50 CONTINUE
CALL FUNA (XXE(KK),YYE(KK),ZZE(KK),B(1),B(2),B(3))
FJ1(I)=FJ1(I)+B(1)
FJ2(I)=FJ2(I)+B(2)
FJ3(I)=FJ3(I)+B(3)
60 CONTINUE
IN=I+NSW
FJ1(IN)=0.
FJ2(IN)=0.
FJ3(IN)=0.
DO 70 J=2, KK
AYT1=-YYE(J-1)
AYT2=-YYE(J)
CALL INFU (XXE(J-1),AYT1,ZZE(J-1),XXE(J),AYT2,ZZE(J),B)
FJ1(IN)=FJ1(IN)+B(1)
FJ2(IN)=FJ2(IN)+B(2)
FJ3(IN)=FJ3(IN)+B(3)
70 CONTINUE
AYT2=-YYE(KK)
CALL FUNA (XXE(KK),AYT2,ZZE(KK),B(1),B(2),B(3))
FJ1(IN)=FJ1(IN)+B(1)
FJ2(IN)=FJ2(IN)+B(2)
FJ3(IN)=FJ3(IN)+B(3)
90 CONTINUE
FJ1(T)=0.
FJ2(T)=0.
FJ3(T)=0.
FJ1(NSW+1)=0.
FJ2(NSW+1)=0.
FJ3(NSW+1)=0.
DO 90 T=1,NSW1
T1=I+1
T2=I+NSW
T3=T2+1
EFJ1=CONS(T)*(FJ1(T2)-FJ1(I)+FJ1(I1)-FJ1(I3))
EFJ2=CONS(T)*(FJ2(T2)-FJ2(I)+FJ2(I1)-FJ2(I3))
EFJ3=CONS(T)*(FJ3(T2)-FJ3(I)+FJ3(I1)-FJ3(I3))
WNG 800
WNG 810
WNG 820
WNG 830
WNG 840
WNG 850
WNG 860
WNG 870
WNG 880
WNG 890
WNG 900
WNG 910
WNG 920
WNG 930
WNG 940
WNG 950
WNG 960
WNG 970
WNG 980
WNG 990
WNG1000
WNG1010
WNG1020
WNG1030
WNG1040
WNG1050
WNG1060
WNG1070
WNG1080
WNG1090
WNG1100
WNG1110
WNG1120
WNG1130
WNG1140
WNG1150
WNG1160
WNG1170
WNG1180
DO 90 J=1,NCW
NP=(I-1)*NCW+J
CONI3(NP)=EFJ1
CONJ3(NP)=EFJ2
CONK3(NP)=EFJ3
90 TOTAL INDUCED VELOCITY
I=1
DO 100 J=1,NWNG
CONI(J)=(CONI(J)+CONI3(J))*SI(I)
CONJ(J)=(CONJ(J)+CONJ2(J)+CONJ3(J))*SI(I)
CONK(J)=(CONK(J)+CONK2(J)+CONK3(J))*SI(I)
I=I+1
IF (I.GT.NCW) I=1
100 CONTINUE
RETURN
END
SUBROUTINE VDTRE (X,Y,Z,CI,CJ,CK,NSW1,BSQDPX,XLE,YLE)
C
EVALUATES INFLUENCE COEFFICIENTS FOR CALCULATION OF INDUCED
C
VELOCITY DUE TO FREE ELEMENTS
COMMON /ALLPAR/ XE(40),YE(40),ZE(40),XXE(30),YYE(30),ZZE(30)
COMMON NCTT/NCT,NCON
COMMON /XYIZI/YI,ZI
DIMENSION CT(1),CJ(1),CK(1),XLE(1),YLE(1),V(3),VVV(3)
C
DIMENSION NF VDNL-(NSW1,3) ** SEE GEDM **
DIMENSION VDNL(19,3)
XI=X
YI=Y
ZI=Z
NCT1=0
C

10
REWIND 4
C
DO 60 I=1,NSW1
C
V(1)=0.*
V(2)=0.*
V(3)=0.*
FJ1=0.*
FJ2=0.*
FJ3=0.*
C
READ (4) KK,(XF(J),YE(J),ZE(J),J=1,KK)
C
K=KK-1
C
VELOCITY DUE TO FREE ELEMENTS AHEAD OF TRAILING-EDGE AND THOSE
C
OVER THE WING
C
DO 20 J=1,K
IF (1.EQ.NCON.AND.J.GT.4.AND.YI.GT.0.) GO TO 20
CALL INFL2 (XF(J),YE(J),ZE(J),XE(J+1),YE(J+1),ZE(J+1),VVV)
V(1)=V(1)+VVV(1)
V(2)=V(2)+VVV(2)
V(3)=V(3)+VVV(3)
20
CONTINUE
IF (1.EQ.NCON.AND.YI.GT.0.) GO TO 30
CALL FUNA (XE(K+1),YE(K+1),ZE(K+1),FJ1,FJ2,FJ3)
C
VDNL(I,1)=V(1)+FJ1
VDNL(I,2)=V(2)+FJ2
C
FRE 10
FRE 20
FRE 30
FRE 40
FRE 50
FRE 60
FRE 70
FRE 80
FRE 90
FRE 100
FRE 110
FRE 120
FRE 130
FRE 140
FRE 150
FRE 160
FRE 170
FRE 180
FRE 190
FRE 200
FRE 210
FRE 220
FRE 230
FRE 240
FRE 250
FRE 260
FRE 270
FRE 280
FRE 290
FRE 300
FRE 310
FRE 320
FRE 330
FRE 340
FRE 350
FRE 360
FRE 370
FRE 380
FRE 390
FRE 400
VTDL(I,3)=V(3)+FJ3  
FJ1=0.  
FJ2=0.  
FJ3=0.  
I1=I+1  
C  
CALL SKIPR (4,NSW1)  
READ (4) IT,(XXE(J),YYE(J),ZZE(J),J=1,II)  
C  
IF (II.EQ.NCT.AND.YI.GT.0.) GO TO 50  
C VELOCITY DUE TO WAKE ELEMENTS  
DO 40 J=1,IT  
CALL INFLO (XXE(J-1),YYE(J-1),ZZE(J-1),XXE(J),YYE(J),ZZE(J),V)  
FJ1=FJ1+V(1)  
FJ2=FJ2+V(2)  
FJ3=FJ3+V(3)  
CONTINUE  
CALL FUNA (XXE(II),YYE(II),ZZE(II),V(1),V(2),V(3))  
FJ1=FJ1+V(1)  
FJ2=FJ2+V(2)  
FJ3=FJ3+V(3)  
CONTINUE  
VTDL(I,1)=VTDL(I,1)-FJ1  
VTDL(I,2)=VTDL(I,2)-FJ2  
VTDL(I,3)=VTDL(I,3)-FJ3  
C  
REWIND 4  
C CALL SKIPR (4,I)  
C  
CONTINUE  
YI=YI  
NCT1=NCTI+1  
IF (NCT1.GT.1) GO TO 80  
DO 70 I=1,NSW1  
CI(I)=VTDL(I,1)  
CJ(I)=VTDL(I,2)  
CK(I)=VTDL(I,3)  
CONTINUE  
GO TO 10  
FRE 410  
FRE 420  
FRE 430  
FRE 440  
FRE 450  
FRE 460  
FRE 470  
FRE 480  
FRE 490  
FRE 500  
FRE 510  
FRE 520  
FRE 530  
FRE 540  
FRE 550  
FRE 560  
FRE 570  
FRE 580  
FRE 590  
FRE 600  
FRE 610  
FRE 620  
FRE 630  
FRE 640  
FRE 650  
FRE 660  
FRE 670  
FRE 680  
FRE 690  
FRE 700  
FRE 710  
FRE 720  
FRE 730  
FRE 740  
FRE 750  
FRE 760  
FRE 770  
FRE 780  
FRE 790
SUBROUTINE FUNA (XT, YT, ZT, FJ1, FJ2, FJ3)
C
* INDUCED VELOCITY DUE TO A VORTEX ELEMENT OF UNIT STRENGTH TRAILING FUND * C
FROM (XT, YT, ZT) TO INFINITY
COMMON /ALLRA/ AA(21), BETA2, TANPH1, B2PH1, AB, D4, AC(2), D4S02
COMMON /XIYIZI/ XI, YI, ZI
DIMENSION A(3), B(3), C(3)
A(1) = XT-XI
A(2) = YT-YI
A(3) = ZT-ZI
B(1) = XT+1-XI
B(2) = YT-YI
B(3) = ZT+TANPH1-ZI
CALL CRSPPO (A, B, C)
CC = SQRT(C(1)*C(1)+C(2)*C(2)+C(3)*C(3))
IF (CC.LE.1.E-10) GO TO 10
D5 = 2.* (R2PH1*(ZT-ZI-XT*TANPH1)-XI)
D4 = XI*XI+BETA2*((YI-YT)**2+(ZT-ZI-XT*TANPH1)**2)
D = 4.*D4*D5-D5*D5
IF (D.LE.1.E-10) GO TO 10
R8 = SQRT(D4*XT*XT+D5*XT+D6)
FJ4 = 2.* (D4S02-(2.*D4*XT*D5)/R8)/Q
FJ1 = (YI-YT)*TANPH1*FJ4
FJ2 = (ZT-ZI*(XT-XT)*TANPH1)*FJ4
FJ3 = -(YT-YI)*FJ4
RETURN
10
FJ1 = 0.
FJ2 = 0.
FJ3 = 0.
RETURN
END
SUBROUTINE INFL2 (X1,Y1,Z1,X2,Y2,Z2,VACL)

INDUCED VELOCITY DUE TO A VORTEX ELEMENT OF UNIT STRENGTH LYING BETWEEN (X1,Y1,Z1) AND (X2,Y2,Z2)

COMMON /ALLRAF/ AA(20), BETA

COMMON /XIYIZI/ XI,YI,ZI

DIMENSION VA(3), VL(3), VAP(3), VBP(3), VLP(3), VAACL(3), VAPCLP(3)

VA(1)=X1-XI
VA(2)=Y1-YI
VA(3)=Z1-ZI
VL(1)=X2-X1
VL(2)=Y2-Y1
VL(3)=Z2-Z1
VAP(1)=VA(1)
VAP(2)=BETA*VA(2)
VAP(3)=BETA*VA(3)
VBP(1)=X2-XI
VBP(2)=BETA*(Y2-YI)
VBP(3)=BETA*(Z2-ZI)
VLP(1)=VL(1)
VLP(2)=BETA*VL(2)
VLP(3)=BETA*VL(3)

CALL CRSPPD (VA,VL,VAACL)
CALL CRSPPD (VAP,VLP,VAPCLP)
CALL DOTPRD (VAPCLP,VAPCLP,DAPCLP)
IF (ABS(DAPCLP).LT.(1.E-10)) GO TO 10
CALL DOTPRD (VBP,VBP,DBP)
BPMOD=SORT(DBP)
CALL DOTPRD (VAP,VAP,DAP)
APMOD=SORT(DAP)
CALLL DOTPRD (VBP,VLP,DBPLP)
DBPLP=DBPLP/APMOD
CALLL DOTPRD (VAP,VLP,DAPLP)
DAPLP=DAPLP/APMOD
CONST=(DBPLP-DAPLP)/DAPCLP
GO TO 20

10 CONST=0
CONTINUE

VAACL(1)=VAACL(1)*CONST
VAACL(2)=VAACL(2)*CONST
VAACL(3)=VAACL(3)*CONST
SUBROUTINE NEWVEL (C, THETP, XEE, YEE, ZEE, XN, YN, XTE, YLE, CONS, DUMMY, CVEG)
INIT, CONJ, CONK, SI, NSW1, NCW, NWNG, CI, CJ, CK, XLE, UU, VV, WW, CPCW1, XCP, YCP, VEL
2GAMA, YMM)
C EVALUATES TOTAL VELOCITY AT POINT (XEE, YEE, ZEE)
COMMON /ALLRA/ AA(17), SINA, COSA, AB(5), BSQD4P
COMMON /GMP/ ITER+1, L1, L2, L3, L4, L5, L6, L7, L8
DIMENSION DUMMY(1), CONJ(1), CONK(1), CI(1), CJ(1), CK(1)
1, C(1), THETP(1), XTE(1), XLE(1), YLE(1), CONS(1), SI(1), CPCW1(1)
2, XCP(1), YCP(1), GAMA(1), YMM(1), XN(NWNG, Z), YN(NWNG, Z), NP(4)
3U(4, 3), V(3)
C IF POINT IS IN THE WING PLANE, THE REGULAR METHOD FOR VELOCITY EVALUATION IS USED.
IF (XEE .LE. 0.00001) GO TO 110
IF (YEE .GT. YMM(NSW1)) GO TO 110
CH1 = XTE(1) - XLF(1)
CH2 = XTF(2) - XLE(2)
XYL = XLE(1) + (YEE - YLE(1)) * (XLE(2) - XLF(1)) / (YLF(2) - YLE(1))
CHY = CH1 + (YLF(1)) * (CH2 - CH1) / (YLF(2) - YLE(1))
X = (XEE - XYL) / CHY
IF (X .LT. 0.00001) .AND. (X .GT. 1.0) GO TO 110
ZC = ZEE / CHY
C IF THE POINT (XEE, YEE, ZEE) IS AT Z/C (LOCAL) LESS THAN ZTOL, THE
C VELOCITY IS OBTAINED BY LINEAR INTERPOLATION OF THE VELOCITIES
C CALCULATED ABOVE FOR FOUR WING CONTROL POINTS AMONG WHICH THE POINT IS
C LOCATED, BY NUMERICAL EXPERIMENTATION ZTOL HAS BEEN OBTAINED TO BE
C 0.2.
ZTOL = 0.2
IF (ZC .GE. ZTOL) GO TO 110
I = 1
IF (YEE .LE. YMM(I)) GO TO 20
10 IF (YEE .GT. YMM(I)) .AND. (YEE .LE. YMM(I+1)) GO TO 20
I = I + 1
IF (I .LT. NSW1) GO TO 10
20 J = 1
IF (X .LT. CPCW1(1)) GO TO 50
30 IF (X .GT. CPCW1(J)) .AND. (X .LE. CPCW1(J+1)) GO TO 40
J = J + 1
IF (J .LT. NCW) GO TO 30
40 NP(1) = (I - 1) * NCW + J
NP(2) = NP(1) + 1
NP(3)=NP(1)+NCW
NP(4)=NP(3)+1
XC1=CPCW1(J)
XC2=CPCW1(J+1)
GO TO 60
50
NP(1)=NCW*NSW1+1
NP(2)=(I-1)*NCW+1
NP(3)=NP(1)+1
NP(4)=NP(2)+NCW
XC1=0.
XC2=CPCW1(1)
CONTINUE
40
EVALUATION OF INDUCED VELOCITY AT FOUR POINTS
DO 80 I=1,4
NN=NP(I)
CALL VOTWNG (C,THETP,XCP(MN),YCP(MA),ZEE,XN,YN,XTE,YLE,CONJS,DUMMY(VEL)
111),DUMMY(L2),DUMMY(L3),DUMMY(L4),DUMMY(L5),DUMMY(L6),DUMMY(L7),DUVEL
2MNY(L9),CONJ,CONK,SI,NSW1,NCW,NWNG)
U(I,1)=0.
U(I,2)=0.
U(I,3)=0.
DO 70 J=1,NWNG
U(I,1)=U(I,1)+CONJ(J)*GAMA(J)
U(I,2)=U(I,2)+CONJ(J)*GAMA(J)
U(I,3)=U(I,3)+CONK(J)*GAMA(J)
70
CONTINUE
80
INTERPOLATION
MN1=NP(1)
MN2=NP(3)
Y1=YCP(MN1)
Y2=YCP(MN2)
DO 90 I=1,3
UA=U(I,1)+(U(3,1)-U(I,1))*(YEE-Y1)/(Y2-Y1)
UR=U(I,2)+(U(3,1)-U(I,1))*(YEE-Y1)/(Y2-Y1)
VI(I)=UA+(UR-UA)*(XC-XC1)/(XCZ-XC1)
UU=VI(I)+COSA
VV=VI(2)
WW=VI(3)+SINA
CALL VOTFRE (XEE,YEE,ZEE,C1,CJ,CK,NSW1,B+D4P,XLE,YLE)
```
C  FINAL TOTAL VELOCITY
DO 100 J=1,NSW1
JJ=NWMG+J
UU=UU+CI(J)*GAMA(JJ)
VV=VV+CJ(J)*GAMA(JJ)
100 WW=WW+CK(J)*GAMA(JJ)
RETURN
C  EVALUATION OF VELOCITY WHEN POINT IS IN THE WING PLANE
110 CONTINUE
CALL VOTNWG (C,THETP,YEE,YEE,ZEE,XN,YN,XLE,YLE,CONS,DUMMY(L1),DUMMYVEL)
CALL VOTFRE (YEE,YEE+ZEE,CI,CJ,CK,NSW1,BSOD4P,XLE,YLE)
C  FREE STREAM VELOCITY
UU=CSA
VV=0.
WW=SINA
C  VELOCITY DUE TO FREE ELEMENTS
DO 120 I=1,NSW1
NOW=NWMG+1
UU=UU+CI(I)*GAMA(NO)
VV=VV+CJ(I)*GAMA(NO)
120 WW=WW+CK(I)*GAMA(NO)
C  VELOCITY DUE TO WING
DO 130 I=1,NSW1
DO 130 J=1,NCW
NO=(I-1)*NCW+J
UU=UU+CONT(NO)*GAMA(NO)
VV=VV+CONJ(NO)*GAMA(NO)
130 WW=WW+CONK(NO)*GAMA(NO)
RETURN
END
VEL 800
VEL 810
VEL 820
VEL 830
VEL 840
VEL 850
VEL 860
VEL 870
VEL 880
VEL 890
VEL 900
VEL 910
VEL 920
VEL 930
VEL 940
VEL 950
VEL 960
VEL 970
VEL 980
VEL 990
VEL 1000
VEL 1010
VEL 1020
VEL 1030
VEL 1040
VEL 1050
VEL 1060
VEL 1070
VEL 1080
VEL 1090
VEL 1100
VEL 1110-
```
OVERLAY (LEVSP,1,0)
PROGRAM GEOM
C DEFINES THE WING AND FREE ELEMENT GEOMETRY
C MAXIMUM VALUES
C ** NCW = 9
C ** NNCW = NCW+1 = 10
C ** NSW = 20
C ** NSW1 = NSW-1 = 19
C ** NWG = NNCH*NSW1 = 190
C. ** NCPWT = (NNCW+1)*NSW1 = 209
COMMON XVL(2),XTT(2),YL(2),CPCW(10),CPCW1(10),SI(10),SN(10),SNN(11)
10,SWP(10),SLOPE(10),XL(2,10),C(19),THEETP(19),CONS(19),CPWSL(19)*XGEO
2LM(19),XTM(19),YLM(19),CTT(19),CPWSL(20),XLE(20),XE(20),YLE(20)*XGEO
3AVWG(190),YAVWG(190),XN(190,2),YN(190,2),XCP(209),YCP(209),X(10)*GEO
420),Y(10,20)
COMMON /ALLI/ NSW,NSW1,NCW,NWNG,NCPWT,MITER,IPUNCH
COMMON /ALLRA/ TTL(16),ALPHA,SINT,COSA,SWPE,BETA,BETA2,TANPH1,B2PGE
1H1,RSQ4P,PD4,COM,PI,D4SO2,CBAR,HALF,AREA
COMMON /XTRN/ XARR(25),NBRR
THEN=5HEND
C
READ (5,130) TTL
IF (TTL(1).EQ.THEND) GO TO 120
READ (5,160) NCW,NSW,NBRR,NCONTS,MITER,IPUNCH
NSW1=NSW-1
READ (5,150) (XVLX),XTX(I),YLY(I),I=1,2
READ (5,150) ALPHA,AMACH,DELTA,DLXEND,CBAR,AREA
READ (5,150) (XBR(1),1=1,NBRR)
READ (5,150) (CTT(1),1=1,NSW1)
C
WRITE (6,170) TTL
WRITE (6,160) NCW,NSW,NBRR,NCONTS,MITER,IPUNCH
WRITE (6,150) (XVLX),XTX(I),YLY(I),I=1,2
WRITE (6,150) ALPHA,AMACH,DELTA,DLXEND,CBAR,AREA
WRITE (6,150) (XBLR(I),I=1,NBRR)
WRITE (6,150) (CTT(1),1=1,NSW1)
NCW=NCW
NCW=NCW+1
C
NPRCY=0, USED FOR BOUND ELEMENTS = (NCW+1)
C
NPRCY=1, USED FOR BOUND ELEMENTS = NCW
GEO 10
GEO 20
GEO 30
GEO 40
GEO 50
GEO 60
GEO 70
GEO 80
GEO 90
GEO 100
GEO 110
GEO 120
GEO 130
GEO 140
GEO 150
GEO 160
GEO 170
GEO 180
GEO 190
GEO 200
GEO 210
GEO 220
GEO 230
GEO 240
GEO 250
GEO 260
GEO 270
GEO 280
GEO 290
GEO 300
GEO 310
GEO 320
GEO 330
GEO 340
GEO 350
GEO 360
GEO 370
GEO 380
GEO 390
GEO 400
NPRCY=0
10 IF (NPRCY.EQ.1) NCW=NCW
   *I=3.14159265
   FN2=2.*NCW
   PI=PI/FLOAT(NCW)
   TWOP=2.*PI
   DO 20 I=1,NCW
      CPCW(I)=50.*(1.-COS((2.*FLOAT(I)-1.)*PI/FN2))
   CPCW(I)=50.*(1.-COS(FLOAT(I)*PI/FLOAT(NCW)))
   CC=CPCW(I)/100.
   SNN(I)=2.*SORT(CC*(1.-CC))
   PSIJI=(2.*FLOAT(I)-1.)*PIJ/2.
   SNI(SNI/PIJ)/TWOP
   SWPIE=ATAN((XXL(1)-XXL(I))/(YL(2)-YL(I)))
   FMZ=2.*NSW
   DO 30 J=1,NSW
   CPSW(I)=50.*(1.-COS((2.*FLOAT(I)-1.)*PI/FM2))
   CPSW(I)=0.
   DO 40 I=1,NSW1
   CPSW(I)=50.*(1.-COS(FLOAT(I)*PI/FLOAT(NSW)))
   CALL PNLWG (NSW,WN,NCW)
   HALFW=YL(I)
   DO 50 I=1,NSW1
   C(I)=XTM(I)-XLM(I)
   YYLM=YLM(I)/HALFW
   50 THEP(I)=ARCSIN(YYLM)
   NCPTT=NSW1+WN
   IF (NPRCY.EQ.1) GO TO 60
   NCW=NCW
C
   REWIND 1
   REWIND 7
   WRITE (1) NCW,WN
   WRITE (1) (SI(I),SNN(I),SWP(I),I=1,NCW)
   WRITE (1) (XAVWG(I),YAVWG(I),I=1,WN,NCW)
   C
   NPRCY=1
   GO TO 10
DO 70 I=1,NCW
CPCWL(I)=CPCWL(I)/100.
70 CPCW1(I)=CPCWL(I)/100.
DO 80 I=1,NSW
80 CPSWL(I)=CPSWL(I)/100.
DO 90 I=1,NSW1
90 CPSW1(I)=CPSW1(I)/100.
C EVALUATING THE CONSTANTS
ALPHA=ALPHA*PI/180.
TANPH1=TAN(ALPHA)
TANPH2=TANPH1*TANPH1
BETA2=1.-AMACH*AMACH
BETA=SQR(BETA2)
B2PH1=BETA2*TANPH1
D4=BETA2*TANPH2+1.
D4SQ2=2.*SQR(D4)
CON=BETA2/(8.*FLOAT(NCW))
BSQ4P=1.E-8*(D4SQ2)
CON1=1./(1.-AMACH*AMACH)
CON2=1./(1.+AMACH*AMACH)
CON3=1.0/CON1
CON4=2.0/CON1
DO 100 I=1,NSW1
100 CTT(I)=CON3*SORT(CON4*CTT(I))
DO 110 I=1,NSW1
110 CONS(I)=CON*CTT(I)
SINA=1.*(SIN(ALPHA))
COSA=1.*(COS(ALPHA))
C WRITE (1) (SNN(I),SWP(I),I=1,NCW)
WRITE (1) (XAVNG(I),YAVNG(I),I=1,NWNG)
WRITE (1) (C(I),I=1,NSW1)
WRITE (1) (THETP(I),I=1,NSW1)
WRITE (1) (XTE(I),XLE(I),YLE(I),I=1,NSW1)
WRITE (1) (XLM(I),YLM(I),I=1,NSW1)
WRITE (1) (CONS(I),I=1,NSW1)
WRITE (1) (SI(I),SN(I),I=1,NCW)
WRITE (1) (XCP(I),YCP(I),I=1,NCPTTL)
WRITE (1) ((XN(I,J),YN(I,J),J=1,2),I=1,NWNG)
SUBROUTINE PNLENG (NSW, Lpanel, NCW)

GENERATES THE GRID OF BOUND AND TRAILING VORTEX ELEMENTS

COMMON XXL(2), XXT(2), YL(2), CPCWL(10), CPCW1(10), SI(10), SN(10), SNN(1)
10, SWP(10), SLOPE(10), XL(2, 10), C(19), THETP(19), CONS(19), CPSW1(19), XPLN
2LM(19), XTM(19), YLM(19), CT(19), CPSW(20), XLE(20), XTE(20), YLE(20), XPLN
3AVWG(190), YAVWG(190), XN(190, 2), YN(190, 2), XCP(209), YCP(209), X(10, PN
420), Y(10, 20)

DO 10 I=1, 2
D=XTT(I)-XXL(I)

DO 10 J=1, NCW
XL(I,J)=XXL(I)*CPCWL(J)*0/100.
SPAN=YL(2)-YL(1)

DO 20 I=1, NCW
SLOPE(I)=(XL(2, I)-XL(I, I))/SPAN

SWP(I)=ATAN(SLOPE(I))

DO 30 K=1, NSW
YK=CPSW(K)*SPAN/100.

YLI=YL(1)+YK

DO 30 J=1, NCW
Y(J*K)=YLI

X(J,K)=XL(1, J)*SLOPE(J)*YK

NSW1=NSW-1

XLE(1)=XXL(1)

XTE(1)=XXT(1)

YLE(1)=Y(1, 1)

DLE=(XXL(2)-XXL(1))/SPAN

DTE=(XXT(2)-XXT(1))/SPAN

DO 40 T=2, NSW

YLE(T)=Y(T-1)

YLM(I-1)=YLE(I)+CPSW(I-1)*SPAN/100.

DLE1=DLE*Y(1, 1)-Y(1, I-1)

DTE1=DTE*Y(1, 1)-Y(1, I-1)

XLE(I)=XLE(I-1)+DLE1

XTE(I)=XTE(I-1)+DTE1

XLM(I-1)=XLE(1)+SPAN*CPSW(I-1)*DLE/100.

XTM(I-1)=XTE(1)+SPAN*CPSW(I-1)*DTE/100.

DO 60 K=1, NSW

NP=(K-1)*NCW

CC=XTM(K)-XLM(K)

DO 60 J=1, NCW

40

DO 60 K=1, NSW

NP=(K-1)*NCW

CC=XTM(K)-XLM(K)

DO 60 J=1, NCW

PML 10

PML 20

PML 30

PML 40

PML 50

PML 60

PML 70

PML 80

PML 90

PML 100

PML 110

PML 120

PML 130

PML 140

PML 150

PML 160

PML 170

PML 180

PML 190

PML 200

PML 210

PML 220

PML 230

PML 240

PML 250

PML 260

PML 270

PML 280

PML 290

PML 300

PML 310

PML 320

PML 330

PML 340

PML 350

PML 360

PML 370

PML 380

PML 390

PML 400
ORIGINAL PAGE IS OF POOR QUALITY
K=J

C

IF (NCONTS,NE,0) WRITE (2) (XXE(J),YYE(J),ZZE(J),J=1,2)

70 WRITE (4) K,(XXE(J),YYE(J),ZZE(J),J=1,K)

C

NNMAX=0

DO 80 I=1,NSW1

80 IF (NNMAX,LT,NNELM(I)) NNMAX=NNELM(I)

C

WRITE (4) NMAX,NNMAX,ZMIN,NCONTS

C

XLNT=XEND-XMN

XMX=XEND

XMX=XEND+0.20*XLNT

YMN=0.

YMX=YL(2)

ZMN=-YL(2)/4.

ZMX=YL(2)/2.

IF (NCONTS,NE,0) GO TO 130

C

READS LOCATION OF LEADING-EDGE ELEMENTS FROM INPUT DATA CARDS

C

REWIND 2

REWIND 4

READ (5,160) (NELM(I),I=1,NSW1)

DO 90 I=1,NSW1

K=NELM(I)

READ (5,150) ((X1,J=1,5),(XE(J),J=6,K))

READ (5,150) ((Y1,J=1,5),(YE(J),J=6,K))

READ (5,150) ((Z1,J=1,5),(ZE(J),J=6,K))

READ (2) (XXE(J),YYE(J),ZZE(J),J=1,5)

90 WRITE (4) K,(XXE(J),YYE(J),ZZE(J),J=1,K)

C

READS LOCATION OF WAKE ELEMENTS FROM INPUT DATA CARDS

READ (5,160) (NNELM(I),I=1,NSW)

DO 100 I=1,NSW

K=NNELM(I)

READ (5,150) ((X1,J=1,2),(XXE(J),J=3,K))

READ (5,150) ((Y1,J=1,2),(YYE(J),J=3,K))

READ (5,150) ((Z1,J=1,2),(ZZE(J),J=3,K))

READ (2) (XXE(J),YYE(J),ZZE(J),J=1,2)
100 WRITE (4) K, (XXF(J), YYE(J), ZZE(J), J=1, K)
WRITE (4) NMAX, NNMAX, ZMIN, NCONTS
REWIND 4
WRITE (6,160) (NELM(I), I=1, NSW)
DO 110 I=1, NSW
READ (4) K, (XE(J), YE(J), ZE(J), J=1, K)
WRITE (6,140) (XE(J), J=1, K)
WRITE (6,140) (YE(J), J=1, K)
110 WRITE (6,140) (ZE(J), J=1, K)
WRITE (6,160) (NELM(I), I=1, NSW)
DO 120 I=1, NSW
READ (4) K, (XXE(J), YYE(J), ZZE(J), J=1, K)
WRITE (6,140) (XXE(J), J=1, K)
WRITE (6,140) (YYE(J), J=1, K)
120 WRITE (6,140) (ZZE(J), J=1, K)
130 WRITE (6,170)
C *************************************************************
RETURN
C 140 FORMAT (14F9.4)
150 FORMAT (10F8.4)
160 FORMAT (10I2)
170 FORMAT (18H END OF INPUT DATA, //)
END
SUBROUTINE PLOTT (XE,YE,ZE,NNM,NS)
C MANIPULATES LEADING-EDGE AND WAKE ELEMENTS COORDINATES IN A FORM
C SUITABLE FOR PLOTTING
COMMON /ALLI/ NSW,NSW1
COMMON /XPLT/ XNN,YMN,ZNX,XMX,YMX,ZMX
DIMENSION NNM(1), XE(NS,1), YE(NS,1), ZE(NS,1), LAY(14), LABZ(14)
DATA LAY/6*6H ,6H VS Y,6*6H ,2H /
DATA LABZ/6*6H ,6H VS Z,6*6H ,2H /
C ******************************************************
REWINO 4
IF (NS.EQ.0,NSW) GO TO 20
DO 10 I=1,NSW1
READ (4) KK,(XE(I,J),YE(I,J),ZE(I,J),J=1, KK)
10 NNM(I)=KK
NC=4
LAMY(8)=6H(LEAD)
LAMY(9)=6HNG-EDG
LAMY(10)=HE ELEM
LAMY(11)=6HENTS)
LAMZ(9)=6HLEAD
LABZ(9)=6HNG-EDG
LABZ(10)=HE ELEM
LABZ(11)=6HENTS)
GO TO 20
DO 30 I=1,NSW1
READ (4)
30 DO 40 I=1,NSW
READ (4) KK,(XE(I,J),YE(I,J),ZE(I,J),J=1, KK)
40 NNM(I)=KK
LAMY(8)=6H(WAKE
LAMY(9)=6HELEVEN
LAMY(10)=6HTS)
LAMY(11)=6H
LABZ(8)=5H(WAKE
LABZ(9)=6HELEVEN
LABZ(10)=6HTS)
LABZ(11)=6H
C ******************************************************
NC=0
60 DO 70 L=2,NS
I=L-1
K=NM(N+1)-NC
DO 60 J=1,K
K=J+NC
XE(I,J)=XE(L,KK)
YE(I,J)=YE(L,KK)
60  ZE(I,J)=ZE(L,KK)
XE(I,K+1)=XNN
YE(I,K+1)=YNN
ZE(I,K+1)=ZNN
XE(I,K+2)=XNN
YE(I,K+2)=YNN
ZE(I,K+2)=ZNN
MM(N)=L+2
MS1=NS-1
CALL LMPLT (XE,YE,NNM,NS1,NS,LABY)
CALL LMPLT (XE,ZE,NNM,NS1,NS,LABZ)
RETURN
END
50 IF (TOP.GE.ZMAX) GO TO 60
TOP = TOP + RANGE
GO TO 50
60 CONTINUE
IF (KEY.EQ.2) GO TO 70
KEY = 2
ZMAX = YMAX
ZMIN = YMIN
YINC = 0.01 * (TOP - BOTTOM)
XINC = YINC * SCALE
XROT = BOTTOM * SCALE
GO TO 20
70 CONTINUE
YINC = 0.0125 * (TOP - BOTTOM)
YLOW = TOP + YINC
YINC = 2. * YINC
WRITE (6, 160)
KEY = 5
80 CONTINUE
DO 90 IJ = 2, 101
90 ALINE (IJ) = BLANK
YHIGH = YLOW
YLOW = YHIGH - YINC
YHS = SCALE * YHIGH
YLS = SCALE * YLOW
DO 110 I = 1, N
N = NELM(I) - 2
DO 110 J = 1, N
IF (Y(I,J).GT.YHS.OR.Y(I,J).LE.YLS) GO TO 110
INDEX = (X(I,J) - XBOT) / XINC
INDEX = INDEX + 1
IF (INDEX.GT.101) INDEX = 101
IF (ALINE(INDEX).NE.BLANK) GO TO 100
ALINE (INDEX) = SYM(I)
GO TO 110
100 ALINE (INDEX) = PLUS
110 CONTINUE
ALINE (1) = UP
IF (KEY.NE.5) GO TO 120
TPP=TOP*SCALE
WRITE (6,170) TPP,ALINE
GO TO 130
120 WRITE (6,180) ALINE
130 CONTINUE
KEY=KEY-1
IF (KEY.EQ.0) KEY=5
TOP=TOP+YINC
IF (TOP.GE.BOTTOM) GO TO 80
IF (KEY.NE.4) GO TO 80
WRITE (6,210) YAXIS
XINC=10.0*XINC
ALINE(I)=XBOT
DO 140 I=2,11
140 ALINE(I)=ALINE(I-1)+XINC
WRITE (6,190) (ALINE(I),I=1,11)
C
WRITE (6,200) (LABEL(I),I=1,14)
150 RETURN
C
160 FORMAT (1HI,/)  
170 FORMAT (F10.3,1X,101A1)  
180 FORMAT (11X,101A1)  
190 FORMAT (5X,11F10.3)  
200 FORMAT (//,20X,13A6,A2)  
210 FORMAT (11X,101A1)  
END
OVERLAY (LEVSP,3,0)
PROGRAM SOLN
SETS UP DIMENSIONS FOR SOLVING THE STRENGTHS OF WING AND LEADING-
EDGE VORTEX SYSTEM
COMMON D(1)
COMMON /ALLI/ NSW,NSW1,NCW,NWNG,NCPTTL
LC=1
LTHETP=LC+NSW
LXTE=LTHETP+NSW
LXLE=LXTE+NSW
LYLE=LXLE+NSW
LCONS=LYLE+NSW
LCTT=LCONS+NSW1
LCPWL=LCTT+NSW1
LCPSW=LCPWL+NCW
LSI=LCPSW+NSW1
LSN=LSI+NCW
LXC=LSN+NCW
LYC=LXC+NCPTTL
LXN=LYC+NCPTTL
LYN=LYX+2*NWNG
LON=LYN+2*NWNG
LCONJ=LON+NWNG
LCON=LCONJ+NWNG
LCI=LCON+NWNG
LCJ=LCI+NWNG
LCK=LCJ+NWNG
LDUM=LCK+NWNG
LNX=LDMY+B*NWNG
LNX=2*NWNG+10*NSW+3*NCW-6
MN=LCJ+(NCPTTL+1)**2/4
MN=(NCPTTL+1)**2/4+10*NWNG+10*NSW+3*NCW-6
CALL AEROND (NWNG,D(LC),D(LTHETP),D(LXTE),D(LXLE),D(LYLE),D(LCONS),NSW,NSW1,NCW,NWNG,NCPTTL)
1, D(LSI), D(LSN), D(LXCP), D(LYCP), D(LXN), D(LYN), D(LON), D(LCON), D(LCONJ), D(LSNI)
2CONK), D(LCI), D(LCJ), D(LCK), D(LDMY), D(LCTT), D(LCPWL), D(LCPWS)
RETURN
END
SLN 10
SLN 20
SLN 30
SLN 40
SLN 50
SLN 60
SLN 70
SLN 80
SLN 90
SLN 100
SLN 110
SLN 120
SLN 130
SLN 140
SLN 150
SLN 160
SLN 170
SLN 180
SLN 190
SLN 200
SLN 210
SLN 220
SLN 230
SLN 240
SLN 250
SLN 260
SLN 270
SLN 280
SLN 290
SLN 300
SLN 310
SLN 320
SLN 330
SLN 340
SLN 350
SLN 360
SLN 370-
SUBROUTINE AERODN (NHWG,C,THETP,XTE,XLE,YLE,CONS,SI,SN,XCP,YCP,XH,AER)
1YN,CONJ,CONJ,CONK,CI,CJ,CLK,DUMMY,CT,CP'/L,CPSW1)
C SOLVES FOR THE STRENGTHS OF WING AND LEADING-EDGE VORTEX SYSTEM
COMMON /ALLI/ NSW,NSW1,NCH,INNG,NCP TTL
COMMON /ALLRA/ AA(17),SINA,A3(6),BSQD4P
COMMON /GM/ ITER,L1,L2,L3,L4,L5,L6,L7,L8
COMMON /NCT/ NCT,NCON
DIMENSION C(1), THETP(1), XTE(1), XLE(1), YLE(1), CONS(1), SI(1), AER
1SN(1), XCP(1), YCP(1), DUMMY(1), CONI(1), CONJ(1), CONK(1), CI(1), AER
2 CJ(1), CK(1), CT(1), CPCWL(1), CPSW1(1), XH(NHWG,2), YN(NHWG,2)
AER 10
AER 20
AER 30
AER 40
AER 50
AER 60
AER 70
AER 80
AER 90
AER 100
AER 110
AER 120
AER 130
AER 140
AER 150
AER 160
AER 170
AER 180
AER 190
AER 200
AER 210
AER 220
AER 230
AER 240
AER 250
AER 260
AER 270
AER 280
AER 290
AER 300
AER 310
AER 320
AER 330
AER 340
AER 350
AER 360
AER 370
AER 380
AER 390
AER 400
C
C INFLUENCE COEFFICIENT MATRIX EVALUATION
L1=1
L2=L1*NHWG
L3=L2*NHWG
L4=L3*NHWG
L5=L4*NHWG
L6=L5*NHWG
L7=L6*NHWG
L8=L7*NHWG
NCH=0
NCT=0
DO 10 I=1,NCP TTL
C
ZCP=0.
CALL VDOTWG (C,THETP,XCP(I),YCP(I),ZCP,XN,YN,XTE,YLE,CONS,DUMMY(L1,AER 410
J),DUMMY(L2),DUMMY(L3),DUMMY(L4),DUMMY(L5),DUMMY(L6),DUMMY(L7),DUMMAER 420
N2Y(L9),CONI,CONJ,CONK,SI,NSW1,NCW,NWNG)
WRITE (2) (CONX(J),J=1,NWNG) AER 450
CALL VDOTFRE (XCP(I),YCP(I),ZCP,CI,CJ,CK,NSW1,BSOD4P,XLE,YLE) AER 460
WRITE (3) (CK(J),J=1,NSW1) AER 470
10 CONTINUE AER 480
C GAMA-EVALUATION AER 490
REWIND 2 AER 500
REWIND 3 AER 510
READ (2) (CONI(I), I=1,NWNG) AER 520
NWNG1=NWNG+1 AER 530
NWNB=NWNG+NSW1 AER 540
NWNB1=NWNB+1 AER 550
READ (3) (CONI(I), I=NWNG1,NWNB) AER 560
CONI(NWNB1)=SINA AER 570
IJ=1 AER 580
DO 20 I=1,NWNB AER 590
CJ(I)=CONI(I+1)/CONI(I) AER 600
I=2 AER 610
NJ=NWNB-1 AER 620
20 CONTINUE AER 630
READ (2) (CONI(I), I=1,NWNG) AER 640
READ (3) (CONI(I), I=NWNG1,NWNB) AER 650
CONI(NWNB1)=SINA AER 660
IF (IJ.GT.NWNG) CONI(NWNB1)=SINA -CT(IJ-NWNG) AER 670
CALL VISEQN (NJ, IJ, CONJ, CJ, CONK) AER 680
IJ=IJ+1 AER 690
NJ=IJ-1 AER 700
IF (IJ.LE.NWNB) GO TO 30 AER 710
WRITE (*,30) AER 720
DO 40 I=1,NSW1 AER 730
DO 40 J=1,NCW AER 740
NP=(I-1)*NCW+J AER 750
40 WRITE (*,70) JPCWL(IJ),JPCW1(IJ),JPCW2(IJ) AER 760
WRITE (*,100) AER 770
DO 50 I=1,NSW1 AER 780
J=NWNG+I AER 790
```fortran
50 WRITE (6,90) CPSWI(I),CJ(J)
C EVALUATION OF SECTIONAL LEADING-EDGE THRUST
CALL THRT (CJ,CONI,CONJ)
NERR=0
DO 60 I=1,NSW1
60 IF (ABS(CONJ(I)-CT(I)) .GE. (1.0E-10)) NERR=1
IF (NERR.EQ.1) WRITE (6,110)
GMSUM=0.
DO 70 I=2,NSW1
70 GMSUI=GMSUM+CJ(KS)
C
REWIND 2
WRITE (2) (CJ(I),I=1,NWB)
WRITE (7) GMSUM
C
RETURN
C
80 FORMAT (1H1,//,22H WING VORTEX STRENGTHS,//,22H
1**/,29H X/C 27/3 GAMAY,//,29H *** ****
2 ****)
90 FORMAT (3F10.5)
100 FORMAT (1/,32H LEADING-EDGE VORICES STRENGTHS,///,31H
1***,///,23H 27/3 CAPSAM,///,23H *** ****
2****)
110 FORMAT (1/,34H ERROR IN SECTIONAL ST CALCULATION,///,10F10.5)
END
```
SUBROUTINE VMSEQN (NC1, KA, CA, A, CA)
C SOLVES A SYSTEM OF SIMULTANEOUS EQUATIONS
DIMENSION AA(1), CA(1), A(1)
NC = K * NC1
SUM1 = 0.
K1 = K - 1
JJ = 1
DO 10 J = 1, K1
SUM1 = SUM1 + AA(J) * A(JJ)
10 JJ = JJ + NC1 + 1
SUM1 = SUM1 + AA(K)
DO 30 I = 1, NC1
SUM2 = 0.
JJ = I + 1
DO 20 J = 1, K1
SUM2 = SUM2 + AA(J) * A(JJ)
20 JJ = JJ + NC1 + 1
KK = K + I
SUM2 = SUM2 + AA(KK)
30 CA(I) = -SUM2 / SUM1
M = 1
L = 0
KNC = (K - 1) * NC1
DO 60 I = 1, NC
IF (I GT KNC) GO TO 50
MM = (M - 1) * NC1 + 1
IF (I EQ MM) GO TO 70
40 KK = KK + 1
IL = I + L
A(I) = CA(KK) * BASE + A(IL)
GO TO 60
50 II = I - KNC
A(I) = CA(II)
60 CONTINUE
GO TO 80
70 II = MM - M - 1
BASE = A(II)
K2 = 0
L = L + 1
M = M + 1
SUBROUTINE THRST (SGM, CONK, CT)
C
EVALUATES SECTIONAL LEADING-EDGE THRUST COEFFICIENTS
COMMON /ALL1/ NSW, NWS1, NCW, NWNG
COMMON /ALLRA/ AA(17), SINA, COSA, SWPE, A3, BETA2, AC(5), PI
DIMENSION SGM(1), CONK(1), CT(1)
AM2=1.-BETA2
FCOS=COS(SWPE)
FTAN=TAN(SWPE)
VAR1=FLOAT(NCW)*SORT(FTAN*FTAN+BETA2)
VAR2=SORT(1.-AM2*FCOS*FCOS)
REWOIND 2
REWOIND 3
CALL SKIPR (2,NWNG)
CALL SKIPR (3,NWNG)
DO 30 I=1,NSW1
WL=0.
READ (2) (CONK(J),J=1,NWNG)
DO 10 J=1,NWNG
10 WL=WL+CONK(J)*SGM(J)
READ (3) (CONK(J),J=1,NWS1)
DO 20 J=1,NWS1
JJ=NWNG+J
20 WL=WL+CONK(J)*SGM(JJ)
THR1=(WL*SINA)/VAR1
30 CT(I)=(PI/2.)*VAR2*THR1*THR1/FCOS
RETURN
END

THR 10
THR 20
THR 30
THR 40
THR 50
THR 60
THR 70
THR 80
THR 90
THR 100
THR 110
THR 120
THR 130
THR 140
THR 150
THR 160
THR 170
THR 180
THR 190
THR 200
THR 210
THR 220
THR 230
THR 240
THR 250
THR 260
THR 270-
OVERLAY (LEVSP,4,0)
PROGRAM LOADS
SETS UP DIMENSIONS FOR EVALUATING AERODYNAMIC CHARACTERISTICS
COMMON :Q(1)
COMMON /ALLI/ NSW,NSWL,NCW,NWNG
DIMENSION W(4100)
NCW=NCW+1
NWNP=NCW+NSWL
LCI=1
LCJ=LCI+NWNG
LCK=LCJ+NWNG
LCNJ=LCK+NWNG
LCNJ=LCK+NWNG
LCNJ=LCK+NWNG
LVWNG=LCNJ+NWNG
LYVWNG=LVWNG+NWNG
LXLE=LYVWNG+NWNG
LXTE=LXLE+NSW
LYLE=LXTE+NSW
EST=LYLE+NSW
LC=LSI+NCW
LSWP=LC+NSWL
LXN=LSWP+NCW
LYN=LXN+2*NWNG
LSNN=LYN+2*NWNG
LTHETP=LSNN+NCW
LCONS=LTHETP+NSWL
LDUMHY=LCONS+NSWL
LCT=LDUMHY+3*NWNG
LOI=LCT+NSWL
LCNI=LCI+NCW
LCNP=LQNN+NCW
LYVNA=LQSNP+NCW
LYVNA=LYVNA+NSWL
LGAM=LYVNA+NSWL
LGM=LGAM+NWNG+NSWL
LXLM=LGM+NSWL
LTIL=LXLM+NSWL
LSCL=LTHT+NCW
LSCH=LSCL+NSWL
SUBROUTINE COEFS (CI, C2, C3, C4, CIH, C1J, C1K, XYAVNG, YAVNG, XLE, XTE, YLCOF 10
LE, SI, C6, SUP, XN, YN, SNH, THET); CONS, DUMMY, CT, OI, OHH, OWSP, XAVWNA, YAVWNCOF 20
2, YAVNG, GAMA, GNL, XLE, THT, SECCL, SECCH, SECCD, COSP, CMC, CPSW, CPSW1, DCPACOF 30
3, DCP, GAMA, GAY, VY, TNEF, DCPN, WX, YW, NSW1) COF 40

COMPUTES THE AERODYNAMIC CHARACTERISTICS COF 50
COMMON /ALLA/ AA(177), SINA, COSA, AB(3), PI, AC, COAR, HALF3, ARFA COF 60
COMMON /NCT/ NCT, NCON COF 70
COMMON /XSTW/ XSTW(25), NSRR COF 80
DIMENSION CI(1), C2(1), C3(1), C4(1), CIH(1), C1J(1), C1K(1), XYAVNG(1)COF 100
1, YAVNG(1), XLE(1), XTE(1), YLE(1), SI(1), C(1), SWP(1), SNN(1), COF 110
2 CT(1), XN(YAVNG, 2), YN(YAVNG, 2), DUMMY(1), GAMA(1), GNL(1), XLE(1), COF 120
3 THT(1), SECCL(1), SECCH(1), SECCD(1), COSP(1), CMC(1), CPSW(1), COF 130
4 CPSW1(1), DCPA(1), DCP(1), GAY(1), GAY(1), VY(1), DCPN(1), WX(1), COF 140
5 WX(1), W1(1), COEF(NSW1, 1), CONS(1), THET(1), OI(1), ONN(1), OWSPCOF 150
6(1), XAVWNA(1), YAVWNA(1) COF 160

RE:WIND 1 COF 170
READ (1) NNCW, NWNP COF 180
READ (1) (Q(I(1), OHH(1), OWS(1), I = 1, NSRR) COF 190
READ (1) (XAVWNA(1), YAVWNA(1), I = 1, NSW1) COF 200
READ (1) (SNN(1), SWP(1), I = 1, NCON) COF 210
READ (1) (YAVWNG(1), YAVWNG(1), I = 1, NCON) COF 220
READ (1) (CIH(1), I = 1, NSW1) COF 230
READ (1) (THT(1), I = 1, NSW1) COF 240
READ (1) (XLE(1), XLE(1), YLE(1), I = 1, NSY) COF 250
READ (1) (XLE(1), YLE(1), I = 1, NSY) COF 260
READ (1) (SI(1), ADND, I = 1, NSD) COF 270
CALL S2PR(1, 1) COF 280
READ (1) (XN(YAVNG, 2), I = 1, XLE) COF 290
READ (1) (CT(1), I = 1, SWP) COF 300
CALL S2PR(1, 2) COF 310
READ (1) (DUMMY(1), I = 1, OHH) COF 320
READ (1) (CPW1(1), I = 1, NSW1) COF 330
READ (1) (CPW1(1), I = 1, NSW1) COF 340
READ (1) (CPW1(1), I = 1, NSW1) COF 350
READ (1) (CPW1(1), I = 1, NSW1) COF 360
READ (1) (CPW1(1), I = 1, NSW1) COF 370
READ (1) (CPW1(1), I = 1, NSW1) COF 380

PIJ = PI/(2, *FLAT_HC(1)) COF 390

C
DO 10 J=1,NCW
10 COSP(J)=COS((2.*FLOAT(J)-1.)*PIJ)
CONST=HALF*PI/(AREA*FLOAT(NSW))
C CALCULATION OF GMY-VALUES FOR WING SURFACE
NCON=0.
NCT=0
DO 20 II=1,NSW1
DO 20 J=1,NCW
I=I*(II-1)*NCW+J
XEE=XAVNG(I)
YEE=YAVNG(I)
ZEE=0.
CALL NEWVEL(C,THETP,XEE,YEE,ZEE,XN,YN,XTE,YLE,CONS,DUMMY,CONT,CONCOF
1J,CONK,S1,NSW1,NCW,NWNG,CI,CJ,CK,XLE,UU,VV,WW,ADUM,BDUM,CDUM,GAMA,COF
2YLM)
TNSP=TAN(SWP(J))
GMY(I)=GAMA(I)*(UU-VV*TNSP)
20 CONTINUE
C READING LARGEP SRTO FOR THE WING
C CALCULATION OF INDUCED VELOCITIES AT SOUND ELEMENT END-POINTS ON
WING SURFACE
DO 40 I=1,NSW1
DO 40 J=1,NCW
NP=(I-1)*NCW+J
XEE=XN(NP+2)
YEE=YN(NP+2)
40 CONTINUE
C CALCULATION OF GAY-VALUES FOR SOUND ELEMENTS NEAR LEADING-EDGE
DO 50 J=1,NCW
50 TIT(J)=(7.*FJ-1.)*PI/(2.*FLOAT(NCW))
SUR=9.*FLOAT(NCW)/(4.*PI*IN(TIT(J)))
DO 40 I=1,NSW1
NSI=NWNG+I
GML(I)=GAMA(NGI)*SURA/C(I)

REIND 3
WRITE (3) (GML(I),I=1,NSW1)

TNSP=TAN(OSWP(I))
D0 70 II=1,NSW1
XEE=XAVVNA(I1)
YEE=YAVVNA(I1)
CALL NEWVEL(C,THETP,XEE,YEE,ZEE,XN,YN,XTE,YLE,CONS,DUMMY,CONI,CONC)
1J,CONK,SI,NSW1,NCW,NNNG,CI,CJ,CX,XLE,UX,UY,WW,ADUM,BDUM,CDUM,GAMA,COF
2YLM)
NWWGII=NNWG+II
GMY(NWWGII)=GML(I1)*(UU-VV*TNSP)
CONTIF

CALCULATION OF OCC-VALUES FOR WING POINTS
PN=PI/(FLOAT(NCW1))
D0 80 I=1,NCW
W(I)=0.
WX(I)=XN(I1,1)
WY(I)=YN(I1,1)
D0 150 I=1,NSW1
D0 140 J=1,NCW
NP=(I-1)*NCW+J
VYV=VY(NP)
CPG=0.
CPH=0.
CPI=0.
D0 100 JJ=1,J
NPIN=(I-1)*NCW+JJ
IF (J.EQ..JJ) GO TO 77 70
CPG=CPG+GAMA(NPIN)*SI(JJ)
GO TO 100
CPG=CPG+0.5*GAMA(NPIN)*SI(JJ)
CONTIF
CPG=CPG*PN*C(I1)*VY
IF (I.EQ..NSW1) GO TO 130
D0 120 JJ=1,J
NPOT=I*NCW+JJ
IF (J.EQ.IJ) GO TO 110
CPH=CPH+GAMA(NPOT)*SI(JJ)
GO TO 120
110  CPH=CPH+0.5*GAMA(NPOT)*SI(JJ)
120  CONTINUE
CPH=CPH*PN*C(J+1)*VYY
130  CPI=2.*GAMA(NWNG+I)*VYY
W(NP+NCW)=CPG*CPH+CPI
WX(NP+NCW)=XN(NP,2)
WY(NP+NCW)=YN(NP,2)
140  CONTINUE
150  CONTINUE
N3=NWNG+NCW+3
CALL SURFSET (N3,WX,WY,W,CJ)
DO 170 K=1,NCW
DO 160 J=1,NSW1
NP=(J-1)*NCW+K
DCP1=2.*GMY(NP)
XEE=XAVWNG(NP)
YEE=YAVWNG(NP)
CALL SURFORD (W,XEE,YEE,VV,N3)
DCPD=VV/(YLE(J+1)-YLE(J))
DCP(NP)=DCP1+DCPD
160  CONTINUE
170  CONTINUE
C    CALCULATION OF INDUCED VELOCITIES AT END-POINTS OF BOUND ELEMENTS
C    NEAR LEADING-EDGE
C       CPC=0.5*(1.-COS(THT(I)))
C       DO 180 I=2,NSW
C       XEE=XLE(I)*CPC*(XLE(I+1)-XLE(I))
C       YEE=YLE(I)
C       CALL NEWVEL (C,THT,F,P,XEE,YEE,ZEE,XN,YN,XY,ELE,CONS,DUMMY,CON,CON)
C       1J,CONK,SI,NSW1,NCW,NWNG,SI,CJ,OX,XLE,UU,VV,WW,ADUM,3DUM,CDUM,GAMA,COF1510
2YLM)
180  YL(I)=VV
C    DCP-INTERPOLATION FOR BOUND ELEMENTS OF WING
C    CALL INTGMY (NCW,NSW1,DCP,SNW,CCF,DUMMY(1),DUMMY(NCW))
C    CALCULATION OF DECREASE IN DCP-VALUES AT THE LEADING-EDGE
DCPA(1)=0.
DCPA(NSW)=0.
DO 190 I=2,NSW1
DCPA(I)=2.*GAMA(NWNG+I)*VY(I)
190 CONTINUE
DO 200 I=1,NSW1
CNC(I)=2.*GMY(NWNG+I)
200 CONTINUE
C FINAL DCP-VALUES AT LARGER WING GRID
DO 230 I=1,NSW1
DO 220 J=1,NNCW
NP=(I-1)*NNCW+J
GMNW(NP)=COEF(I,1)
DO 210 K=1,NCW
FK=K
AM1=COS(FK*THT(J))
AM2=AM1*COEF(I,K+1)
GMNW(NP)=GMNW(NP)+AM2
210 CONTINUE
GMNW(NP)=GMNW(NP)/(SIN(THT(J)))
IF (J,NE,1) GO TO 220
NGI=NWNG+I
GMNW(NP)=GMNW(NP)+CNC(I)
220 CONTINUE
230 CONTINUE
DO 240 I=1,NHWP
DCP(I)=GMNW(I)
240 CONTINUE
PIJ=PI/(2.*FLOAT(NNCW))
WRITE (4,370)
DO 250 I=1,NSW1
DO 250 J=1,NNCW
NP=(I-1)*NNCW+J
COS=PIJ*PI/(1.-COS((2.*FLOAT(J)-1.)*PIJ))
WRITE (4,330) CPSW(CPSW=I),DCP(NP)
DO 250 J=1,NNCW
250 CONTINUE
C EVALUATION OF SECTIONAL AND TOTAL AERODYNAMIC CHARACTERISTICS
CL=0.
CM=0.
CD=0.
CTT=0.
DO 280 I=1,NSW1
SECC(I)=0.
SECM(I)=0.
PHII=PI+FLOAT(I)/FLOAT(NSW)
DO 270 J=1,NNCW
NP=(I-1)*NNCW+J
SECC(I)=SECC(I)+DCP(NP)*QI(J)
SECM(I)=SECM(I)-DCP(NP)*QI(J)*(XLM(I)+0.5*C(I)*(1.-COSP(J)))/CBA
1R
270 CONTINUE
SECC(I)=SECC(I)*PI/(2.*FLOAT(NNCW))
SECM(I)=SECM(I)*PI/(2.*FLOAT(NNCW))
SECD(I)=SECC(I)*SINA-CT(I)*COSA
SECD(I)=SECC(I)*COSA+CT(I)*SINA
CL=CL+SECC(I)*C(I)*SIN(PHII)
CM=CM+SECM(I)*C(I)*SIN(PHII)
CD=CD+SECD(I)*C(I)*SIN(PHII)
280 CTT=CTT+CT(I)*C(I)*SIN(PHII)
CL=CONST*CL
CM=CONST*CM
CD=CONST*CD
CTT=CONST*CTT
C
WRITE (7) CL,CM,CD,CTT
C
WRITE (6,340) (I,SECC(I),SECM(I),SECD(I),CT(I),I=1,NSW1)
WRITE (6,350) CL,CM,CD,CTT
NNCW1=NNCW+1
CALL INTGMY (NNCW,NSW1,DCP,NN,CJEF,DUMMY(1),DUMMY(1))
RECORD 1
CALL 3XPR(1,8)
READ (1) (XLM(I),CI(I),I=1,NSW1)
C
EVALUATION OF DCP AT CONSTANT X LOCATIONS
DO 330 K=1,NARR
XBR=XARR(K)
KY=1
290 IF (XBR.LT.XLM(KY)) GO TO 300
KY=KY+1
000a0000000a00000000n0000000
000a0000000a00000000n0000000

IF (K Y .LE. NSW1) GO TO 290

300 KY=KY-1
BLOCAL=CI(KY)+(CI(KY+1)-CI(KY))*(XBR-XLM(KY))/(XLM(KY+1)-XLM(KY))
DO 320 I=1,KY
CJ(I)=CI(I)/BLOCAL
XC=(XBR-XLM(I))/C(I)
THTA=ARCCOS(1.-2.*XC)
DCPN(I)=COEF(I,1)
DO 310 J=1,NNC

310 DCPN(I)=DCPN(I)+COEF(I,J+1)*COS(FLOAT(J)*THTA)

320 DCPN(I)=DCPN(I)/(SIN(THTA))
WRITE (6,360) XBR*(CI(I),CJ(I),DCPN(I),I=1,KY)

330 CONTINUE
RETURN
END

C

340 FORMAT (1H1,1H,9X,20HSECTIONAL PROPERTIES,9X,20H***********COF2510
1****,9X,39HCLI CMICDI CTI,9X,39H* COF2520
2 *** *** *** ***,/(II10,4F10.5))

350 FORMAT (/9X,23HTOTAL LIFT COEFFICIENT=F10.5,9X,34HTOTAL PITCHICOF2540
1NG MOMENT COEFFICIENT=F10.5,9X,23HTOTAL DRAG COEFFICIENT=F10.5COF2550
2F9X,25HTOTAL THROU COEFFICIENT=F10.5COF2560

360 FORMAT (1H34HSPANWISE PressURES AT CONSTANT X=F10.5,8X,25HMF COF2570
1 2Y/B LOCAL DELTA-CP/,(/1X,2F10.5,2X,F10.5))

370 FORMAT (1H1,1H,5X,21HDELA-CP DISTRIBUTION,5X,21H**********COF2590
1*****,30H X/C 2Y/B DELTA-CP/,30H *** ***COF2600
2* *********)

380 FORMAT (3F10.5)

END
SUBROUTINE INTHM (NCY, NSW1, SGH, SNN, COEF, F, THETA)
C SETS UP COEFFICIENTS OF A MATRIX FOR DCP-INTERPOLATION
DIMENSION SGH(1), SNN(1), F(1), THETA(1), COEF(NSW1,1)
PI=3.14159265
N1=NCW+1
FN=NCW
DO 40 I=1, NSW1
DO 10 J=1, NCW
NK=(I-1)*NCW+J
FJ=J
THETA(J)=(2.*FJ-1.)*PI/(2.*FN)
10 F(J)=SGH(NK)*SNN(J)
DO 30 J=1, N1
COEF(I,J)=0.
FJ=J
DO 20 K=1, NCW
COEF(I,J)=COEF(I,J)+F(K)*COS((FJ-1.)*THETA(K))
20 IF (J.EQ.1) COEF(I,J)=COEF(I,J)/FN
IF (J.NE.1) COEF(I,J)=COEF(I,J)*2./FN
30 CONTINUE
40 CONTINUE
RETURN
END
SUBROUTINE SURFSET (N3,X,Y,W,IWK)
C     SET UP PROGRAM FOR SURFACE SPLINE
C     WRITTEN BY - ROBERT N. DESMARAI, STRUCTURES AND DYNAMICS DIV.
C     LANGUAGE RESEARCH CENTER, HAMPTON, VA. 23665

DIMENSION X(1), Y(1), W(N3,1), IW(K)
E=1.0, E=10
NZ=1
N=N3-3
N1=N+1
N2=N+2
N4=N3+1
RN=1.*N
N3Z=N3*NZ
NZ3=NZ+3

C     COMPUTE SCALING PARAMETERS, UB, UX, UY, VB, VX, XY
X8=0.
Y8=0.
PXX=0.
PXY=0.
PYY=0.
TH=0.

DO 10 1=1,N
X8=X8+X(I)
Y8=Y8+Y(I)
PXX=PXX+X(I)*X(I)
PXY=PXY+X(I)*Y(I)
PYY=PYY+Y(I)*Y(I)

10  X8=RN*X8
Y8=RN*Y8
PXX=RN*PXX-X8*Y8
PXY=RN*PXY-X8*Y8
PYY=RN*PYY-Y8*Y8
IF (PXY.>N.E.0) TH=.5*ATAN2(2.*PXY,PYY-PXX)
CT=CSI(TH)
ST=SIN(TH)
C2=CT*CT
CS=2.*CT*ST
S2=ST*ST
SU=1./SQRT(PXX+C2-PXY*CS+PYY+S2)
SV=1./SQRTPX+CS+PYY+C2)
UX=SU*CT
UY=-SU*ST
VX=SV*ST
VY=SV*CT
UB=-(UX*XB+UY*YB)
VB=-(VX*X9+VY*Y9)

C PUT Z INTO ITS W LOCATION
IZ=N*NZ
DO 30 J=N4,N3Z
DO 20 I=1,3
20 W(I,J)=0
DO 30 I=4,N3
W(I,N3+6+4-N-J)=W(IZ+1)
30 IZ=IZ-1

C PUT 1,U,V (SCALED X,Y) INTO THEIR W LOCATIONS
DO 40 I=N1,N3
DO 40 J=1,3
40 W(I,J)=0
DO 50 J=1,N
JR=N4-J
W(I,J)=1.
W(JR,N1)=W(I,J)
W(2,J)=UB+UX*X(J)+UY*Y(J)
W(JR,N2)=W(2,J)
W(3,J)=VB+VX*X(J)+VY*Y(J)
W(JR,N3)=W(3,J)
50 DO 60 J=1,N
60 JB=N4-J

C COMPUTE H MATRIX IN W
DO 60 I=N4,JB
IB=N4-I
R2=(W(2,J)-W(2,I))**2+(W(3,J)-W(3,I))**2
W(I,J)=R2*ALOG(R2+E)
60 W(JD,IB)=W(I,J)

C MATINV IS THE SYSTEM LIBRARY ROUTINE FOR SOLVING LINEAR EQUATIONS
N31=N3+1
CALL MATINV (N3,N31,W,1,W(1,N31),1,DET,ISCIWK,IKW(N4))

C PUT S,U,V IN LOW W
W(1,1)=N3*(3+N7)
W(2,1)=N
W(3,1)=E
DO 70 I=1,N
W(I+3,1)=O
W(I+2)=UB+UX*X(I)+UY*Y(I)
W(I+3)=VB+VX*X(I)+VY*Y(I)
W(N1,2)=UR
W(N2,2)=UX
W(N3,2)=UY
W(N1,3)=VR
W(N2,3)=VX
W(N3,3)=VY
IF (NZ.EQ.0) RETURN
DO 90 J=4,NZ3
DO 80 I=1,N3
C LEFT SHIFT ARRAYS N COLUMNS
W(I,J)=W(I,N+J)
RETURN
END
SUBROUTINE SURFORD (W,XP,YP,ZP,N3)
SURFACE SPINE INTERPOLATION (ORDINATES)
WRITTEN BY - ROBERT N. DESJARLIS, STRUCTURES AND DYNAMICS DIV.
LANGLY RESEARCH CENTER, HAMPTON, VA.23665

DIMENSION W(N3,1)
N=N3-3
N1=N+1
N2=N+2
U=W(N1,2)+W(N2,2)*XP+W(N3,2)*YP
V=W(N1,3)+W(N2,3)*XP+W(N3,3)*YP
ZP=W(N1,4)+W(N2,4)*U+W(N3,4)*V
DO 10 I=1,N
R2=(U-W(I,2))**2+(V-W(I,3))**2
10 ZP=ZP+W(I,4)*R2*ALNG(R2+W(I,3,1))
RETURN
END
SUBROUTINE MATINV (MAX,N,A,M,B,IOPT,DETERM,ISCALE,IPIVOT,IMK)
MATRIX INVERSION WITH ACCEOMPANYING SOLUTION OF LINEAR EQUATIONS
PROVIDED BY - ANALYSIS AND COMPUTATION DIVISION
LANGLEY RESEARCH CENTER
HAMPTON, VA. 23665
DIMENSION IPIVOT(N), A(MAX,N), B(MAX,N), IMK(MAX,2)
EQUIVALENCE (IROW,JROW), (ICOLUMN,JCOLUMN), (AMAX,T,SWAP)

INITIALIZATION

ISCALE=0
R1=10.0*100
R2=1.0/R1
DETERM=1.0
DO 10 J=1,N
10 IPIVOT(J)=0
DO 370 I=1,N

SEARCH FOR PIVOT ELEMENT

AMAX=0.0
DO 60 J=1,N
IF (IPIVOT(J)-1) 20,60,20
20 DO 50 K=1,N
IF (IPIVOT(K)-1) 30,50,410
30 IF (ABS(AMAX)-ABS(A(J,K))) 40,50,50
40 IRW=J
ICOLUMN=K
AMAX=A(J,K)
50 CONTINUE
60 CONTINUE
IF (AMAX) 80,70,80
70 DETERM=0.0
ISCALE=0
GO TO 410
80 IPIVOT(ICOLUMN)=IPIVOT(ICOLUMN)+1

INTERCHANGE ROWS TO PUT PIVOT ELEMENT ON DIAGONAL

IF (IROW-ICOLUMN) 90,130,90
90  DETERM=DETERM
  DO 100 L=1,N
  SWAP=A(IRON+L)
  A(IRON+L)=A(ICOLUMN+L)
100  A(ICOLUMN+L)=SWAP
  IF (N) 130,130,110
110  DO 120 L=1,N
  SWAP=B(IRON+L)
  B(IRON+L)=B(ICOLUMN+L)
120  B(ICOLUMN+L)=SWAP
  INK(I,1)=IRON
  INK(I,2)=ICOLUMN
  PIVOT=AIMCOLUMN,ICOLUMN)
  IF (IOP.EQ.1) GO TO 270
  IF (PIVOT) 140,70,140
C
C  SCALE THE DETERMINANT
C
140  PIVOT=PIVOT
  IF (ABS(DETERM)-R1) 170,150,150
150  DETERM=DETERM/R1
  ISCALE=ISCALE+1
  IF (ABS(DETERM)-R1) 200,160,160
160  DETERM=DETERM/R1
  ISCALE=ISCALE+1
  GO TO 200
170  IF (ABS(DETERM)-R2) 130,130,200
180  DETERM=DETERM/R1
  ISCALE=ISCALE-1
  IF (ABS(DETERM)-R2) 170,190,200
190  DETERM=DETERM/R1
  ISCALE=ISCALE-1
  200  IF (ABS(PIVOT)-R1) 230,210,210
210  PIVOT=PIVOT/R1
  ISCALE=ISCALE+1
  IF (ABS(PIVOT)-R1) 250,220,220
220  PIVOT=PIVOT/R1
  ISCALE=ISCALE+1
  GO TO 240
230 IF (ABS(PIVOT)-R2) 240,240,260
240 PIVOT=PIVOT*R1
ISCALE=ISCALE-1
IF (ABS(PIVOT)-R2) 250,250,260
250 PIVOT=PIVOT*R1
ISCALE=ISCALE-1
260 DETERM=DETERM*PIVOT
C
C DIVIDE PIVOT ROW BY PIVOT ELEMENT
C
270 IF (PIVOT) 280,70,280
280 A(ICOLUMN,ICOLUMN)=1.0
DO 290 L=1,N
290 A(ICOLUMN,L)=A(ICOLUMN,L)/PIVOT
IF (M) 320,320,300
300 DO 310 L=1,N
310 B(ICOLUMN,L)=B(ICOLUMN,L)/PIVOT
C
C REDUCE NON-PIVOT ROWS
C
320 DO 370 L1=1,N
IF (L1-ICOLUMN) 330,370,330
330 T=A(L1,ICOLUMN)
A(L1,ICOLUMN)=0.0
DO 340 L=1,N
340 A(L1,L)=A(L1,L)-A(ICOLUMN,L)*T
IF (M) 370,370,350
350 DO 360 L=1,N
360 B(L1,L)=B(L1,L)-B(ICOLUMN,L)*T
370 CONTINUE
C
C INTERCHANGE COLUMNS
C
DO 400 I=1,N
L=N+1-I
IF (IWK(L,1)-IWK(L,2)) 330,400,330
380 JROW=IWK(L,1)
JCOLUMN=IWK(L,2)
DO 390 K=1,N
SWAP = A(K, JROW)
A(K, JROW) = A(K, JCOLUMN)
A(K, JCOLUMN) = SWAP

390 CONTINUE
400 CONTINUE
410 RETURN
END
SUBROUTINE NEWELM (C, THETP, XN, YN, XTE, YLE, XLE, YLE, CONS, CI, CJ, NELM, 10
1, CK, CONI, CONJ, CONK, DUMMY, NYNG, NCPTTL, XE, YE, XXE, YXE, XZE, YZE, NSW1, 20
2, NSW, ZHIH, NMAX, NMIN, NHEL, NNELM, NCOTS, GAMA, GML, YLM, CPCW1)  NLM 30
C COMPUTES THE NEW LOCATIONS OF LEADING-EDGE AND TRAILING-EDGE  NLM 30
C VORTICES BY MAKING THOSE FORCE-FREE  NLM 30
COMMON /GM/ ITER  NLM 30
COMMON /NCOTT, NCT, NCON  NLM 70
COMMON /ALLRA, TTL(15), ALPHA, SINA, AA(9), PI, AO(2), HALFB, AREA  NLM 80
DIMENSION DUMMY(1), CONI(1), CONJ(1), CONK(1), CI(1), CJ(1), CK(1)  NLM 90
1, C(1), THETP(1), XTE(1), XLE(1), YLE(1), CONS(1), SI(1), KC(1)  NLM 100
2, YCP(1), GAMA(1), GML(1), YLM(1), CPCW1(1), XN(NYNG, 2), YN(NYNG, 2)  NLM 110
3, NELM(1), NNELM(1), XE(NSW1, 1), YE(NSW1, 1), XE(NSW1, 1), YXE(NSW1, 1)  NLM 120
4, YXE(NSW1, 1), ZZE(NSW1), A(3), B(3), F(3)  NLM 130
C ........................................................................................................... NLM 140
REWIN 1  NLM 140
C ........................................................................................................... NLM 140
CALL SKIPR (1, 5)  NLM 150
READ (1) (C(I), I = 1, NSW1)  NLM 160
READ (1) (THETP(I), I = 1, NSW1)  NLM 170
READ (1) (XTE(I), XLE(I), YLE(I), I = 1, NSW)  NLM 180
READ (1) (XLM, YLM(I), I = 1, NSW1)  NLM 190
READ (1) (CONS(I), I = 1, NSW1)  NLM 200
READ (1) (ST(I), AC(I), I = 1, NCW)  NLM 210
READ (1) (XCPI(I), YCP(I), I = 1, NCPTTL)  NLM 220
READ (1) (XN(I), YN(I), J = 1, 2, I = 1, NYNG)  NLM 230
CALL SKIPR (1, 2)  NLM 240
READ (1) (CPCW1(I), I = 1, NCW)  NLM 250
REWIN 2  NLM 260
READ (2) (GAMA(I), I = 1, NCPTTL)  NLM 270
REWIN 3  NLM 280
READ (3) (GML(I), I = 1, NSW1)  NLM 290
REWIN 4  NLM 300
DO 10 I = 1, NSW1  NLM 310
READ (4) XXE(I, J), YXE(I, J), XXE(I, J), J = 1, KK)  NLM 320
NELM(I) = KK  NLM 330
DO 20 I = 1, NSW1  NLM 340
READ (4) XXE(I, J), YXE(I, J), ZXE(I, J), J = 1, KK)  NLM 350
NNELM(I) = KK  NLM 360
C ........................................................................................................... NLM 370
3HALF = 1.25*HALFB  NLM 380
ATL = 1.0 - 0.1 * FLOAT(ITER)
IF (NCONTS .NE. 0) ATL = 0.75
IF (ATL .LT. 0.75) ATL = 0.75
BTL = 1.0 - ATL

EVALUATION OF FORCE ACTING ON LEADING-EDGE ELEMENTS
TFABS = 0.
TLNTH = 0.
NCT = 0
DO 40 I = 2, NSW1
NCON = I
K = NELM(I) - 1
FABS = 0.
ALNTH = 0.
DO 30 J = 5, K
XEE = (XE(I, J) + XE(I, J + 1))/2.
YEE = (YE(I, J) + YE(I, J + 1))/2.
ZEE = (ZE(I, J) + ZE(I, J + 1))/2.
CALL NEWVEL (C, THETP, XEE, YEE, ZEE, XN, YN, XTE, YLE, CONS, DUHMY, CONI, CONNL, 580
1J, CONK, SI, NSW1, NCW, NWNG, CI, CJ, CK, XLE, UU, VV, WW, CPCW1, XCP, YCP, GAMA, YNL)
2LM)
GMA = GAMA(NWNG+1)
A(1) = XE(I, J+1) - XE(I, J)
A(2) = YE(I, J+1) - YE(I, J)
A(3) = ZE(I, J+1) - ZE(I, J)
AAA = SQRT(A(1)*A(1) + A(2)*A(2) + A(3)*A(3))
A(1) = A(1)*GMA/AREA
A(2) = A(2)*GMA/AREA
A(3) = A(3)*GMA/AREA
B(1) = UU
B(2) = VV
B(3) = WW
CALL CRSPRD (A, B, F)
FABS = SQRT(F(1)*F(1) + F(2)*F(2) + F(3)*F(3))
FABS = FABS + FABSI
ALNTH = ALNTH + AAA
30 CONTINUE
TFABS = TFABS + FABS
TLNTH = TLNTH + ALNTH
40 CONTINUE
TAVRG=TFABS/TLNTH
WRITE (6,170) TFABS
C
**********
WRITE (7) TFABS,TAVRG,TLNTH
C
**********
C CALCULATION OF THE COORDINATES OF LEADING-EDGE ELEMENTS BY
C SATISFYING FORCE-FREE CONDITION
DO 110 J=5,NMAX
DO 110 I=2,NSW1
NCON=1
K=NELM(I)-1
IF (J.GT.K) GO TO 110
XXX=XE(I,J+1)
YYY=YE(I,J+1)
ZZZ=ZE(I,J+1)
DLS=SORT((XE(I,J+1)-XE(I,J))**2+(YE(I,J+1)-YE(I,J))**2+(ZE(I,J+1)-
1ZE(I,J))**2)
XEE=(XE(I,J)+XE(I,J+1))/2.
YEE=(YE(I,J)+YE(I,J+1))/2.
ZEE=(ZE(I,J)+ZE(I,J+1))/2.
CALL NEWVEL (C,THETP,XEE,YEE,ZEE,XN,YN,XTE,YLE,CONS,DUMMY,CONI,CONNL,LM000
1J,CONK,SI,NSW1,NCW,NWNG,CI,CJ,CK,XLE,UX,YY,WW,CPCW1,XCP,YCP,GAMA,YML
2LM)
UVW=SORT(UU+UU+VV+VV+WW+WW)
IF (J.EQ.5) GO TO 50
VVA=ATL*VV/UVW
WWA=ATL*WW/UVW
DLV=YVA+DLS*BTL*(YE(I,J+1)-YE(I,J))
DLZ=WVA*DLS*BTL*(ZE(I,J+1)-ZE(I,J))
GO TO 60
CONTINUE
VVA=0.5*VV/UVW
WWA=0.5*WW/UVW
DLV=YVA+DLS+0.5*(YE(I,J+1)-YE(I,J))
DLZ=WVA+DLS+0.5*(ZE(I,J+1)-ZE(I,J))
GO TO 70
CONTINUE
60 CONTINUE
IF ((DLZ/DLS).GT.SINA) DLZ=DLZ+SINA
70 CONTINUE
YINT=YE(I,J)+DLY
ZINT=ZE(I,J)+DLZ
IF (YINT.LE.YE(2,5)) YINT=YE(2,5)
IF (YINT.GE.BHALF) YINT=BHALF
IF (ZINT.LE.ZMIN) ZINT=ZMIN
DLY2=YINT-YE(I,J)
DLZ2=ZINT-ZE(I,J)
DLX22=DSL*DSL-DLY2*DLY2-0LZ2*0LZ2
IF (DLX22.LE.0.) DLY2=DLY2/2.
IF (DLX22.LE.0.) DLZ2=DLZ2/2.
DLX2=SQRT(DSL*DSL-DLY2*DLY2-0LZ2*0LZ2)
XE(I,J+1)=XE(I,J)+DLX2
YE(I,J+1)=YE(I,J)+DLY2
ZE(I,J+1)=ZE(I,J)+DLZ2
DX=XE(I,J+1)-XXX
DY=YE(I,J+1)-YYY
DZ=ZE(I,J+1)-ZZZ
J2=J+2
KP=K+1
IF (J2.GT.KP) GO TO 110
DO 80 JK=J7,JK
XE(I,JK)=XE(I,JK)+DX
YE(I,JK)=YE(I,JK)+DY
ZE(I,JK)=ZE(I,JK)+DZ
C
REWIND 4
DO 90 L=1,NSW1
KS=NELM(L)
WRITE (4) KS,(XE(L,M),YE(L,M),ZE(L,M),M=1,KS)
DO 100 L=1,NSW
KS=NNELM(L)
WRITE (4) KS,(XXE(L,M),YYE(L,M),ZZE(L,M),M=1,KS)
WRITE (4) NMAX,NMAX,ZMIN,NCONTS
C
C CALCULATION OF THE COORDINATES OF WAKE ELEMENTS BY SATISFYING
C FORCE-FREE CONDITION
C
C CTL=0.5
C DTL=1.-CTL
C
NCOND=0
DO 160 J=1,NNMAX
DO 160 I=2,NSW
NCIT=I
K=NNELM(I)-1
IF (J.GT.K) GO TO 160
XXX=XSE(I,J+1)
YYY=YSE(I,J+1)
ZZZ=ZSE(I,J+1)
WLS=SQRT((XSE(I,J+1)-XSE(I,J)**2+(YSE(I,J+1)-YSE(I,J)**2+(ZSE(I,J)**2)
1J+1)-ZSE(I,J)**2)
XSE=(XSE(I,J)+XSE(I,J+1))/2.
YSE=(YSE(I,J)+YSE(I,J+1))/2.
ZSE=(ZSE(I,J)+ZSE(I,J+1))/2.
CALL NEWVEL(C,THETP,XEE,YEE,ZEE,XN,YN,XTE,YTE,CONS,DUMMY,CONI,CONNL
1J,CONK,SI,NSWI,NCW,NCW,G1,CJ,CK,XLE,UX,UX,UX,UX,W,CPW1,CP,CP,CPM,
2LM)
UWW=SQRT(UU*UU+VV*VV+WW*WW)
IF (J.EQ.1) GO TO 130
VVA=CTL*VV/UWW
WVA=CTL*WW/UWW
DLY=VVA+WLS+DTL*(YSE(I,J+1)-YSE(I,J))
DLZ=WVA+WLS+DTL*(ZSE(I,J+1)-ZSE(I,J))
IF ((DLZ/WLS)*GT.SINA) DLZ=WLS*SINA
YINT=YSE(I,J)+DLY
IF (YINT.LE.(YLE(2)/2.)) YINT=YLE(2)/2.
IF (YINT.GE.BHALF) YINT=BHALF
DY2=YINT-YSE(I,J)
DLY2=DLZ
DLYX2=WLS*WLS-DLY2*DLY2-DLY2*DLZ2
IF (DLY2*LE.0.) DLY2=DLY2/2.*
IF (DLY2*LE.0.) DLZ2=DLZ2/2.*
DLY2=SQRT(WLS*WLS-DLY2*DLY2-DLY2*DLZ2)
XSE(I,J+1)=XSE(I,J)+DLYX2
YSE(I,J+1)=YSE(I,J)+DLYX2
ZSE(I,J+1)=ZSE(I,J)+DLZX2
DX=XSE(I,J+1)-XXX
DY=YSE(I,J+1)-YYY
DZ=ZSE(I,J+1)-ZZZ
END
NLHZ190
NLHZ2100 ม
NLHZ190
NLHZ2100 ม
NLHZ2140
NLHZ3100
NLHZ2310
NLHZ2120
NLHZ110
NLHZ000
NLHZ2070
NLHZ2060
NLHZ2050
NLHZ2040
NLHZ2030
NLHZ2020
NLHZ2010
NLHZ2000
IF (25.5T*KP) GE 10 130
KP=KP+1
Z=Z+2
128
This document describes in detail the necessary information for using a computer program to predict distributed and total aerodynamic characteristics for low aspect-ratio wings with partial leading-edge separation. The flow is assumed to be steady and inviscid. The wing boundary condition is formulated by the Quasi-Vortex-Lattice method. The leading-edge separated vortices are represented by discrete free vortex elements which are aligned with the local velocity vector at mid-points to satisfy the force free condition. The wake behind the trailing-edge is also force free. The flow tangency boundary condition is satisfied on the wing, including the leading- and trailing-edges.

The program is restricted to delta wings with zero thickness and no camber. It is written in Fortran language and runs on CDC 6600 Computer.