E.2 LADSON

This is the NASA program that provides a reasonable approximation to the NACA 6 and 6A series airfoils. It was written by Charles Ladson and Cuyler Brooks (Ref E.2-1). Originally it ran on the NASA CDC computer. It has been ported to run on a personal computer (Macintosh). Only minor modifications were made to produce a program to generate a set of ordinates in the form required as standard input by the programs described in App. D.

The program is only an approximation to the ordinates because there is no simple algebraic formula available to describe the thickness distribution. I spoke briefly to Charles Ladson some years ago, and he said that he thought it would be impossible to generate a more accurate program. When he was doing this work he investigated the availability of more detailed notes on these airfoils and discovered that all the records have been destroyed. The only information available is that contained in the actual NACA reports. However, this program is much more accurate than attempts to simulate the 6 and 6A series thickness envelope by using a modified NACA 4-digit airfoil formula. The program was developed to handles thicknesses from 6 to 15 percent.

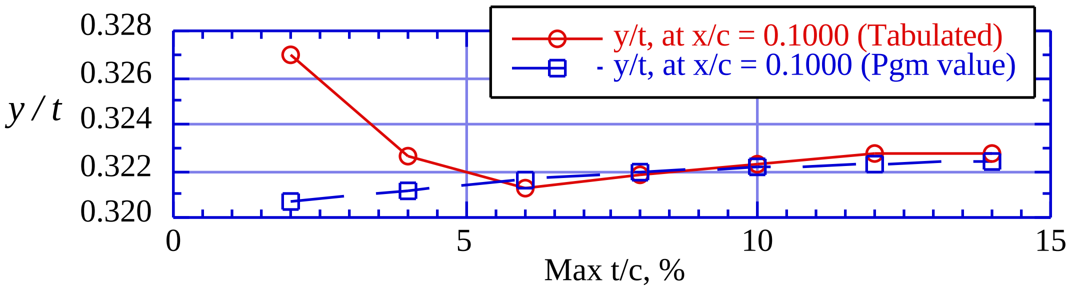
Figure E.2-1 compares the program predictions with the official ordinates - which are given in Ref E.2-2, for 64-series airfoils. If the thickness distribution could be obtained by scaling a reference airfoil, each curve would be a straight flat line. Note especially that below thickness of around six percent the program deviates significantly from the tabulated values.

One other possible problem is the value at the trailing edge. Originally further processing was required to find the value. The program was modified to linearly extrapolate the values near the trailing edge to get the final values. This was the approach recommended by Ladson. This is done in the new routine added to generate the file of points, **stdout**. The user should check this approximation if the results appear to be in error at the trailing edge.

References

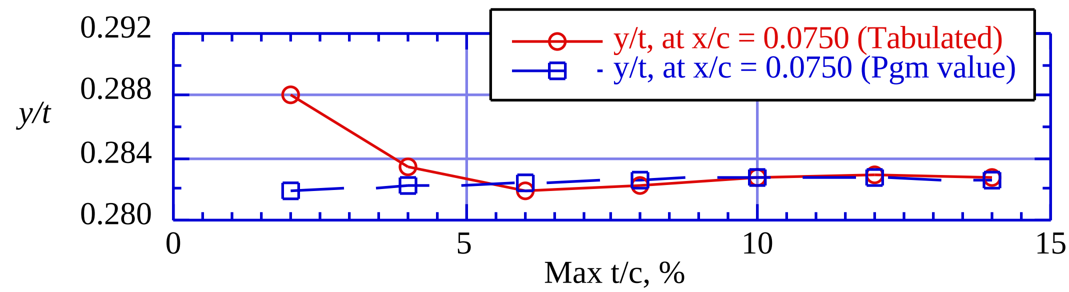
E.2-1. Ladson, C.L., and Brooks, C.W., Jr., "Development of a Computer Program to Obtain Ordinates for NACA 6- and 6A-Series Airfoils," NASA TM X-3069, Sept., 1974.

E.2-2. Patterson, E.W., and Braslow, A.L., "Ordinates and Theoretical Pressure Distribution Data for NACA 6- and 6A- Series Airfoil Sections with Thicknesses from 2 to 21 and from 2 to 15 Percent Chord Respectively," NASA R-84, 1961.

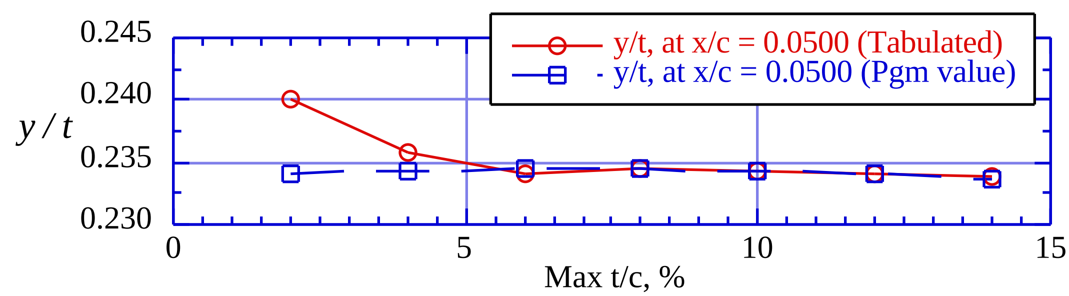


a. x/c = 0.10

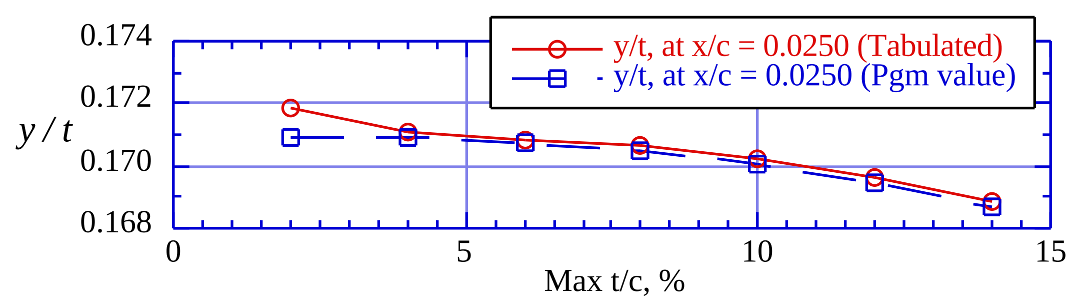
Fig. E.2-1 Comparison of tabulated and computed airfoil ordinate values.



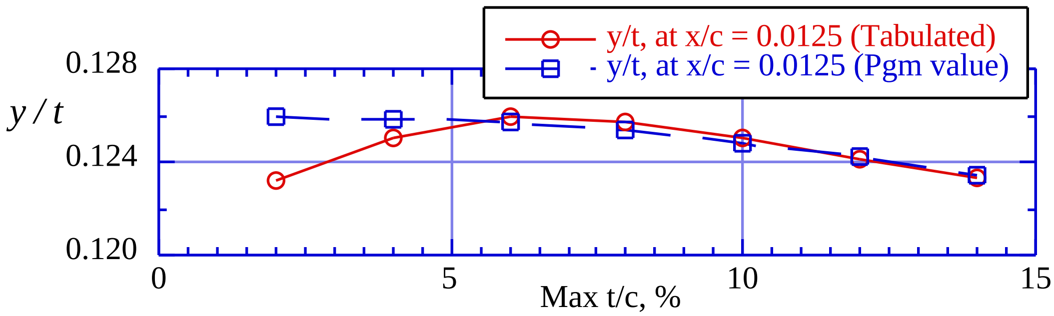
b. x/c = 0.075



c. x/c = 0.050

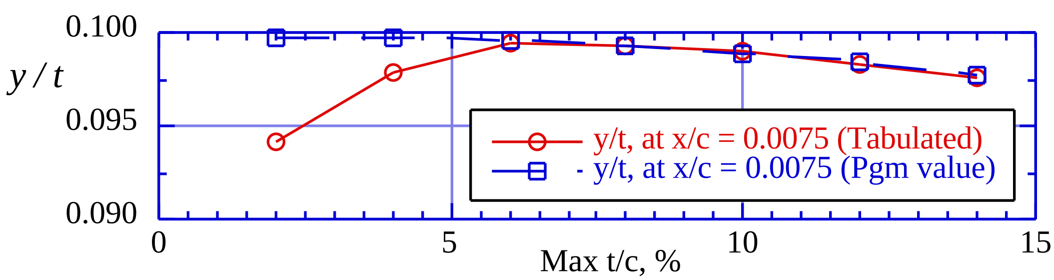


d. x/c = 0.025

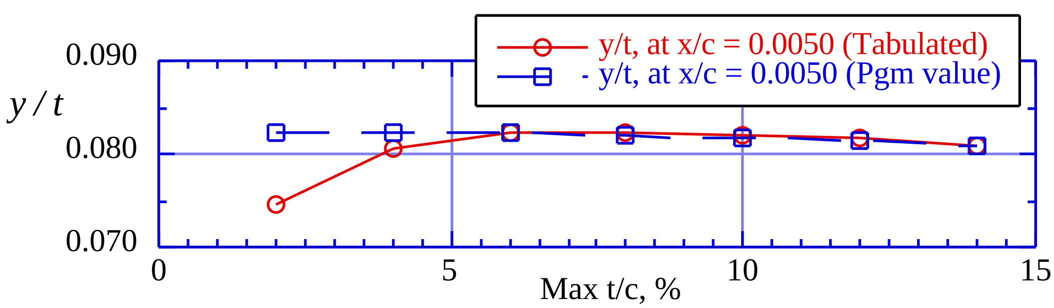


e. x/c = 0.0125

Fig. E.2-1 Comparison of tabulated and computed airfoil ordinate values. (continued)



f. x/c = 0.0075



g. x/c = 0.0050

Fig. E.2-1 Comparison of tabulated and computed airfoil ordinate values. (concluded)

Input Description

The user first creates a data file as described below. Then, the program runs interactively. It queries the user for the name of the input data file. After the airfoil ordinates are found, the user is asked for the name of the output file containing the ordinates in standard format. The file names can be up to twenty characters long. Because the program was developed in the era of cards, it is critically important that the input be placed in the specified column.

Card	Field	Variable	Description
1.	2-80	TITLE	Case title card. Any values can be used, from columns 2 to 80

2. Airfoil and camber line series designations as follows:

NACA airfoil thickness family:		card designation	column
	63-series	63	9,10
	64-series	64	9,10
	65-series	65	9,10
	66-series	66	9,10
	67-series	67	9,10
	63A-series	63A	8,9,10
	64A-series	64A	8,9,10
	65A-series	65A	8,9,10

NACA Camber line		card designation	column
	NACA 6-series	63	19,20
		64	19,20
		65	19,20
		66	19,20
	NACA 6A-series	63A	18,19,20
		64A	18,19,20
		65A	18,19,20

Airfoil Parameter card (Note cards 3 to 6 are in floating point mode. Numbers are entered with a decimal point.

3.	1-10	TOC	Thickness to chord ratio of airfoil, *i.e.*, 0.120
	11-20	LER	Published leading-edge radius may be entered if desired (not used in program)
	21-30	CHD	model chord used for listing ordinates in dimensional units
	31-40	CLI	Design lift coefficient (*i.e.*, 0.20) set to 0.0 for a symmetrical airfoil
	41-50	A	mean line chordwise loading (use 0.8 for 6A-series airfoils)
	51-60	CMBNMR	number of mean lines to be summed, up to a max of nine (if only one, leave blank or insert 1.0)

and as required:

Card	Field	Variable	Description
4.	1-10	CLI	design lift for second mean line
	11-20	A	loading for second mean line
	21-30	CLI	design lift for third mean line
	31-40	A	loading for third mean line
	41-50	CLI	design lift for fourth mean line
	51-60	A	loading for fourth mean line
	61-70	CLI	design lift for fifth mean line
	71-80	A	loading for fifth mean line

Card	Field	Variable	Description
5.	1-10	CLI	design lift for sixth mean line
	11-20	A	loading for sixth mean line
	21-30	CLI	design lift for seventh mean line
	31-40	A	loading for seventh mean line
	41-50	CLI	design lift for eighth mean line
	51-60	A	loading for eighth mean line
	61-70	CLI	design lift for ninth mean line
	71-80	A	loading for ninth mean line
6.	1-10	CLI	design lift for tenth mean line
	11-20	A	loading for tenth mean line

Sample input:

```
   NACA 65(1)213 A=0.5,CL=0.2
        65        65
 0.130     0.00      1.0       0.2         0.5     1.0
```

Output

The program files also contain the sample output of the program. Because the program was written many years ago, it uses 133 column output, and doesn't fit on a normal page. The output file corresponds to the input data set given above and also available in the program files. This case should be verified before further use of the program.

Eighty values of the upper and lower surface are contained in the disk file. The following is the file generated from the sample input listed above. All numbers are output in 2F10.6 format.

```
  NACA 65(1)213 A=0.5,CL=0.2
80.000000 80.000000
 UPPER SURFACE
 0.000000  0.000000
 0.000294  0.004049
 0.000862  0.005724
 0.001472  0.007026
 0.002106  0.008120
 0.002756  0.009078
 0.003416  0.009940
 0.004095  0.010729
 0.004801  0.011465
 0.005750  0.012363
 0.006706  0.013187
 0.007668  0.013957
 0.008635  0.014674
 0.009605  0.015351
 0.010578  0.015999
 0.013509  0.017790
 0.018419  0.020432
 0.023349  0.022801
 0.028292  0.024990
 0.033243  0.027041
 0.038202  0.028978
 0.043167  0.030816
 0.048138  0.032564
 0.053113  0.034230
 0.058093  0.035824
 0.063077  0.037355
 0.068064  0.038829
 0.073053  0.040252
 0.078045  0.041628
```

```
0.083040  0.042963
0.088036  0.044256
0.093035  0.045510
0.098035  0.046725
0.108042  0.049051
0.118054  0.051242
0.138096  0.055281
0.158154  0.058909
0.178228  0.062180
0.198314  0.065122
0.218410  0.067761
0.238517  0.070119
0.258632  0.072209
0.278755  0.074040
0.298885  0.075621
0.319022  0.076953
0.339166  0.078041
0.359316  0.078893
0.379473  0.079505
0.399636  0.079849
0.419807  0.079905
0.439987  0.079653
0.460179  0.079093
0.480389  0.078208
0.500661  0.076988
0.520914  0.075401
0.541078  0.073489
0.561197  0.071293
0.581282  0.068840
0.601339  0.066166
0.621370  0.063297
0.641379  0.060250
0.661367  0.057038
0.681337  0.053682
0.701290  0.050202
0.721229  0.046629
0.741156  0.042982
0.761071  0.039263
0.780978  0.035493
0.800877  0.031693
0.820771  0.027893
0.840662  0.024115
0.860553  0.020383
0.880445  0.016732
0.900341  0.013196
0.920244  0.009825
0.940156  0.006682
0.960082  0.003866
0.980027  0.001528
0.990009  0.000616
1.000000 -0.000015
LOWER SURFACE
0.000000  0.000000
0.001206 -0.003782
0.002138 -0.005234
0.003028 -0.006330
0.003894 -0.007228
0.004744 -0.008000
0.005584 -0.008681
0.006405 -0.009295
0.007199 -0.009859
0.008250 -0.010536
0.009294 -0.011145
0.010332 -0.011704
0.011365 -0.012216
0.012395 -0.012692
0.013422 -0.013143
0.016491 -0.014363
```

```
0.021581 -0.016110
0.026651 -0.017640
0.031708 -0.019033
0.036757 -0.020325
0.041798 -0.021536
0.046833 -0.022676
0.051862 -0.023751
0.056887 -0.024766
0.061907 -0.025730
0.066923 -0.026652
0.071936 -0.027533
0.076947 -0.028381
0.081955 -0.029197
0.086960 -0.029988
0.091964 -0.030750
0.096965 -0.031487
0.101964 -0.032198
0.111958 -0.033552
0.121946 -0.034818
0.141904 -0.037129
0.161846 -0.039182
0.181772 -0.041014
0.201686 -0.042644
0.221590 -0.044089
0.241483 -0.045366
0.261368 -0.046480
0.281245 -0.047440
0.301115 -0.048251
0.320978 -0.048913
0.340834 -0.049428
0.360684 -0.049806
0.380527 -0.050043
0.400364 -0.050111
0.420192 -0.049996
0.440012 -0.049680
0.459821 -0.049171
0.479611 -0.048463
0.499339 -0.047570
0.519085 -0.046504
0.538922 -0.045258
0.558802 -0.043842
0.578717 -0.042267
0.598660 -0.040559
0.618629 -0.038730
0.638620 -0.036789
0.658632 -0.034743
0.678662 -0.032603
0.698709 -0.030384
0.718770 -0.028110
0.738843 -0.025795
0.758928 -0.023432
0.779021 -0.021039
0.799122 -0.018629
0.819228 -0.016226
0.839337 -0.013846
0.859446 -0.011507
0.879554 -0.009237
0.899658 -0.007062
0.919755 -0.005023
0.939843 -0.003175
0.959916 -0.001603
0.979971 -0.000444
0.989990 -0.000089
1.000000 -0.000015
```