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Composite Blade Structural Analyzer (COBSTRAN) Demonstration Manual

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COMPOSITE BLADE STRUCTURAL ANALYZER

COBSTRAN

DEMONSTRATION MANUAL

by

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STRUCTURAL MECHANICS BRANCH

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INTRODUCTION

The purpose of this manual is to show sample deck setups for the pre- and postprocessing features of COBSTRAN. Problems 1 thru 4 demonstrate modeling blades which are solid thru-the-thickness and problems 5 thru 7 demonstrate modeling aircraft wing airfoils with and without internal spars. This manual is intended for use in conjunction with the COBSTRAN USER'S MANUAL. A detail description of all Card Groups and the format for each can be found in the USER'S MANUAL. A dictionary of all program variables and terms used in this manual may be found in Section 6 of the USER'S MANUAL. Interpretation or discussion of the finite element structural analysis shown in these problems is not provided here.

OPTIONS	1	2	3	4	5	6	7
	PROBLEMS						
PREPROCESSING	X	X	X	X	X	X	X
POSTPROCESSING	X	X	X		X		
SOLID BLADE	X	X	X	X			
SHELL/SPAR					X	X	X
CONE ANGLE					X	X	
COSMIC NASTRAN	X	X	X		X	X	
DIAG							X
ECHO	X	X	X	X	X	X	
EZREAD				X			
MPLOTS							X
MSC NASTRAN				X			X
PLYORDER	X	X	X		X		X
PRESSURE			X		X		
PROFILE						X	
PROPERTY INPUT			X				
PRTOUT	X	X				X	
ZIGZAG SPARS							X
PARAMETERS							
IGRD (1,2,3,4)	1	2	1	3			
IMAT (1 thru 8)	2	2	2	4	1	1	1
KSMF (0,1,2,3,4)	2	0	0		0		
MESH (1,2,3,4)	4	2	4	2			

COBSTRAN Demonstration Manual

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PROBLEM NO. 1

This example demonstrates the basic characteristics of the datasets required to implement the COBSTRAN code.

It is suggested that a new user test the code using this small problem to get a sample of the output from COBSTRAN without generating the large quantity of output normally associated with COBSTRAN postprocessing.

This simple flat plate is loaded such that ply failure will be indicated in the postprocessing phase. The user is encouraged to modify this problem by changing thicknesses and/or chord widths to demonstrate the interpolating capabilities within the code.

PREPROCESSOR DECK DESCRIPTION

CARD GROUP 2

These are the program options for this COBSTRAN problem. Each option is described in detail in the COBSTRAN USER'S MANUAL. For this case the preprocessor is called to generate a mesh of one element thru-the-thickness. An echo of the input data and a full printout is requested for output. A COSMIC NASTRAN bulk data deck will be generated for the model and the user will specify the ply layup order to be used to calculate material properties.

CARD GROUP 3

Required ENDOPTIONS card.

CARD GROUP 4

Anisotropic material properties generated for each node are to be based on reduced bending properties and are requested by IMAT = 2. The number of material systems(plys) to be described in Card Group 11 of this input deck are designated by NDES = 3.

CARD GROUP 5

Node number 8 is designated for detailed output of ply properties as indicated by NOPLY = 8. Forty two ply properties will be printed for each ply layer at this grid point. Three cross sections will be used to define the plate and this is indicated by NSECT = 3.

CARD GROUP 6

The form of the grid point input indicated by IGRD = 1 is (X Y ZU ZL TU TL PU PL). The number of sections desired for output is indicated by IU = 15 and the number of nodes output per chord is indicated by JU = 5. Quadrilateral elements are requested by MESH = 4.

CARD GROUP 7

Each of the three chordwise sections will be defined by two grid definitions.

CARD GROUP 8

The blade will be interpolated/extrapolated spanwise between the two span dimensions specified by XBEG = 0.0 and XEND = 10.5.

CARD GROUP 9

Input for three chordwise sections is provided in the form specified by IGRD = 1 (CARD GROUP 6). Pressure is indicated on the surface but PLOAD cards will not be generated because no PRESSURE option is indicated.

CARD GROUP 11

Three composite layers are specified. Each ply is represented by two physical records.

The first record defines the location of the ply on the blade by percent of thickness, span and chord. The first two values on this record refer to the initial and final percent thickness of the thickest grid point of the blade. The thickness calculated from the difference in these values divided by the ply thickness will determine the maximum number of layers of this particular ply at all other grid points, not to exceed the actual thickness at each grid point. The next two values are the initial and final percent span and the last two are initial and final percent chord as shown in Figure 10 of the USER'S MANUAL.

Note: Initial and final percent thicknesses are ignored when the PLYORDER option is specified.

The second record specifies fiber type, matrix type, ply thickness, void volume ratio, fiber volume ratio and orientation angle in degrees relative to the structural x-axis as shown in Figure 6 of the USER'S MANUAL.

CARD GROUP 13

The ply stack-up order for half-thickness is designated by 38 plys starting at the outer surface. Only the number of plys needed to fill the thickness will be used. If an insufficient number of plys is available an ERROR message will be printed. The ply designation numbers correspond to the order in which the plys are listed in CARD GROUP 11.

PREPROCESSOR DECK

CARD GROUP DESIGNATION

```
         1         2         3         4         5         6         7         8
1........0.........0.........0.........0.........0.........0.........0.........0

1- TITLE= DEMONSTRATION PROBLEM NO. 1
1- TITLE=     CANTILEVER BEAM
2- PREPROCESSING
2- SOLID BLADE
2- PRTOUT DESIRED
2- ECHO
2- COSMIC NASTRAN
2- PLYORDER SPECIFIED
3- ENDOPTIONS
4-    2   3
5-    8   3
6-    1  15   5   4
7-    2   2   2
8-   0.0     10.5
9-   0.0     -1.5     .075   -.075                      0.0      10.0
9-   0.0      1.5     .075   -.075                      0.0      10.0
9-   5.0     -1.5     .075   -.075                      0.0      10.0
9-   5.0      1.5     .075   -.075                      0.0      10.0
9-  10.0     -1.5     .075   -.075                      0.0      10.0
9-  10.0      1.5     .075   -.075                      0.0      10.0
11- 0.0       0.0       0.0       100.0     0.0       100.0
11- T300 EPOX  .005      0.0        .60       -45.0
11- 0.0       0.0       0.0       100.0     0.0       100.0
11- T300 EPOX  .005      0.0        .60       +45.0
11- 0.0       0.0       0.0       100.0     0.0       100.0
11- T300 EPOX  .005      0.0        .60        0.0
13-   38
13-    1   3   2   3   1   3   2   3   1   3   2   3   1   3   2   3   1   3   2   3
13-    1   3   2   3   1   3   2   3   1   3   2   3   1   3   2   3   3   3
```

DATABANK

```
         1         2         3         4         5         6         7         8
1........0.........0.........0.........0.........0.........0.........0.........0

 1
T300 ANIS 10-26-79 NO REF.
  3000 .0003
 1
0.0       .064      32000000.  2000000.  .20       .25      1300000.  700000.
-.00000055 .0000056 580.       58.       .17       350000.  300000.   0.0
0.0       0.0       0.0
 1
EPOX ISO  10-26-79 NO REF.
 1
 0.0      .0443     500000.   .41       .000057   1.25      .25       .225
 15000.   21000.    7000.     .014      .042      .032      .038
 1
T300/EPOX 10-26-79
 1.0      4.0       1.0       2.0       1.0       4.0
 1.0      2.0       1.0       1.0       1.05      1.05
 1.0      .16       1.0       1.0       .70       .70
 1.37     .80       13.3      31900.    16.5      .70
 1.0      1.0       1.0       1.0       1.0
```

NASTRAN Deck

```
NASTRAN FILES=PLT2
ID   DEMO NO. 1
APP  DISP
SOL  1,0
TIME 60
CEND
TITLE = CANTILEVER BEAM
      SPC = 25
      DISP = ALL
      LOAD = 2
      SPCF = ALL
      STRESS(PRINT,PUNCH) = ALL
   OUTPUT(PLOT)
      SET 1 = ALL
      AXES = MZ,MY,X
      VIEW = 0.0,0.0,0.0
      FIND SCALE  ORIGIN 1  SET 1
   PLOT
BEGIN BULK
FORCE      2       61             12.5    0.0      0.0     1.0
FORCE      2       62             25.0    0.0      0.0     1.0
FORCE      2       63             25.0    0.0      0.0     1.0
FORCE      2       64             25.0    0.0      0.0     1.0
FORCE      2       65             12.5    0.0      0.0     1.0
SPC       25       1     13456
SPC       25       2     13456
SPC       25       3     123456
SPC       25       4     13456
SPC       25       5     13456
GRDSET                                                     6
```

POSTPROCESSOR DECK

```
 CARD GROUP DESIGNATION
 |
 |          1         2         3         4         5         6         7         8
 |  1.......0.........0.........0.........0.........0.........0.........0.........0
 |
1- TITLE= DEMONSTRATION PROBLEM NO. 1
1- TITLE=     CANTILEVERED PLATE
2- POSTPROCESSING
2- SOLID BLADE
2- PRTOUT DESIRED
3- ENDOPTIONS
4-    2   0   0
```

CARD GROUP 2

Three option cards are used in this postprocessing deck. POSTPROCESSING and SOLID specify that postprocessing of two-dimensional stress output from a structure modeled using the SOLID blade format. PRTOUT indicates that all output is to be printed. That is, stress, strain and failure criteria for every ply layer at every grid point. Also, interply stresses and margins of safety for all ply interfaces at every grid point.

CARD GROUP 3

Required ENDOPTIONS card.

CARD GROUP 4

The three integer values on this card are KSMF, NXSECT and NSPAR. KSMF is used to select the method for calculating the strain magnification factor which will be used in establishing the limiting stress values for each ply layer in each node. Setting KSMF = 2 selects Daniel's indirect method. If the user is not familiar with the options available the default value of 0 is recommended. The other integers in this card group are for the SHELL/SPAR option and may be neglected for this problem because the SOLID option is selected in Card Group 2.

PLOT OF DEMO NO. 1

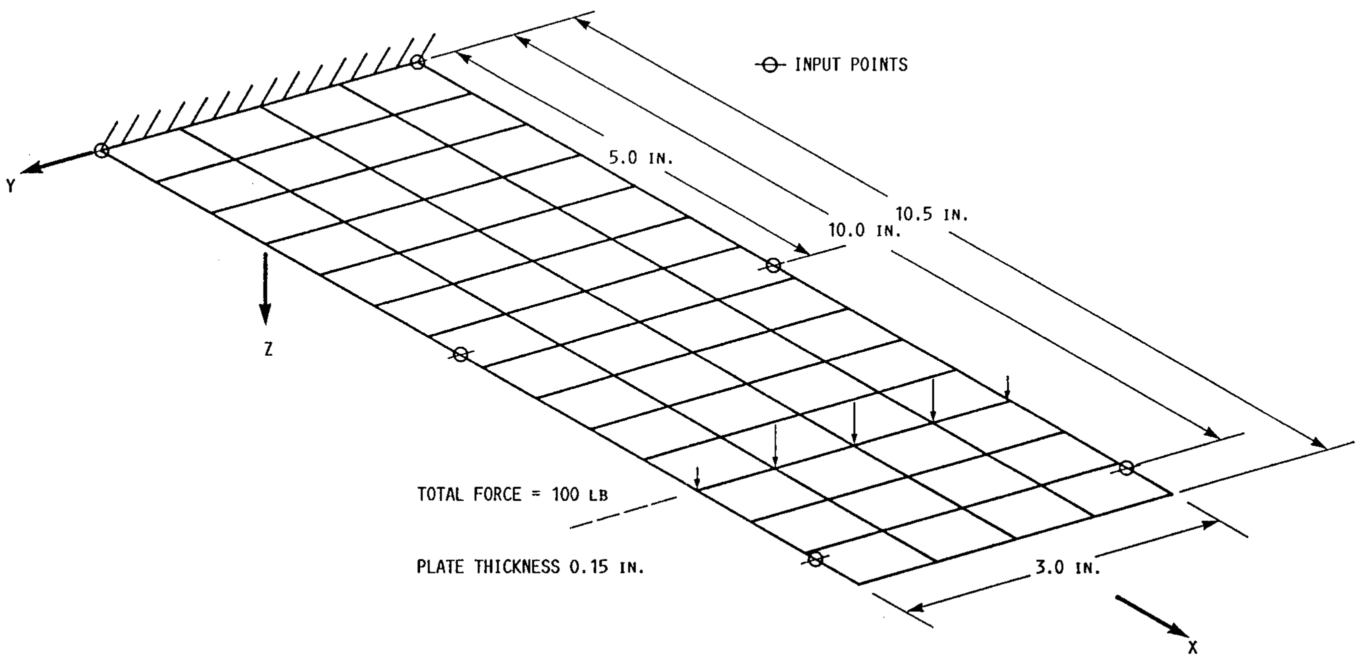


FIGURE 1. - DEMONSTRATION PROBLEM NUMBER 1, CANTILEVER BEAM.

PROBLEM NO. 2

This problem demonstrates the application of a ply surface inlay to change the characterisics of a turboprop blade originally designed with all graphite/epoxy composites. The Boron/aluminum inlay will lie on the surface between 20 to 80 per cent of span and between 15 to 85 per cent of chord.

PREPROCESSOR DECK DESCRIPTION

CARD GROUP 2

These are the program options for this COBSTRAN problem. Each option is described in detail in the COBSTRAN USER'S MANUAL. For this case the preprocessor is called generating a mesh of one element thru-the-thickness. An echo of the input data and a full printout is requested for output. A COSMIC NASTRAN bulk data deck will be generated for the model and PLYORDER indicates that the user will supply the ply layup order in Card Group 13 to be used to calculate material properties.

CARD GROUP 3

Required ENDOPTIONS card.

CARD GROUP 4

Anisotropic material properties generated for each node are to be based on reduced bending properties and are requested by IMAT = 2. The number of material systems(plys) to be described in Card Group 11 of this input deck are designated by NDES = 5.

CARD GROUP 5

Node number 174 is designated for detailed output of ply properties as indicated by NOPLY = 174. Forty two ply properties will be printed for each ply layer at this grid point. Thirty one cross sections will be used to define this blade and is indicated by NSECT = 31.

CARD GROUP 6

The form of the grid point input indicated by IGRD = 1 is (X Y ZU ZL TU TL PU PL). The number of sections desired for output is indicated by IU = 31 and the number of nodes output per chord is indicated by JU = 9. Quadrilateral elements are requested by MESH = 4.

CARD GROUP 7

Each of the thirty one chordwise section definitions will contain 7,8 or 9 grid point coordinates and/or loads.

CARD GROUP 8

The blade will be interpolated/extrapolated spanwise between the two span dimensions specified by XBEG = 2.060 and XEND = 12.25.

CARD GROUP 9

Input for thirty one chordwise sections is provided in the format X Y ZU ZL for each grid point.

CARD GROUP 11

Five composite layers are specified. Each ply is represented by two physical records. The boron/aluminum ply is the inlaid ply and does not exist over the full blade. Fiber and matrix is the same for the other four plys but the orientation angle or thickness is different.

The first record defines the location of the ply on the blade by percent of thickness, span and chord. The first two values on this record refer to the initial and final percent thickness of the thickest grid point of the blade. The thickness calculated from the difference in these values divided by the ply thickness will determine the maximum number of layers of this particular ply at all other grid points, not to exceed the actual thickness at each grid point. The next two values are the initial and final percent span and the last two are initial and final percent chord as shown in Figure 10 of the USER'S MANUAL.

Note: Initial and final percent thicknesses are ignored when the PLYORDER option is specified.

The second record specifies fiber type, matrix type, ply thickness, void volume ratio, fiber volume ratio and orientation angle in degrees relative to the structural x-axis as shown in Figure 6 of the USER'S MANUAL.

CARD GROUP 13

The ply stack-up order for half-thickness is designated by 111 plys starting at the outer surface. Only the number of plys needed to fill the thickness will be used. If an insufficient number of plys is available an ERROR message will be printed. The ply designation numbers correspond to the order in which the plys are listed in CARD GROUP 11.

PREPROCESSOR DECK

CARD GROUP DESIGNATION

```
          1         2         3         4         5         6         7         8
 1........0.........0.........0.........0.........0.........0.........0.........0

1- TITLE= DEMONSTRATION PROBLEM NO.2
1- TITLE= GRAPHITE/EPOXY TURBOPROP BLADE WITH
1- TITLE= SURFACE INLAYS OF BORON ALUMINUM
2- PREPROCESSOR
2- ECHO
2- PRTOUT DESIRED
2- SOLID BLADE
2- COSMIC NASTRAN
2- PLYORDER SPECIFIED
3- ENDOPTIONS
4-    2   5   0   0   0
5-  174  31   0   0
6-    1  31   9   4
7-    7   7   7   7   7   7   7   7   7   7   8   9   9   9   9   9   9   9   9   9
7-    9   9   9   9   9   9   9   9   9   9   9
8-    2.060     12.25
9-    2.0600  -.4710   .2936  -.2936
      2.0600  -.3470   .4331  -.4331
      2.0600  -.1980   .5185  -.5185
      2.0600   .0000   .5550  -.5550
      2.0600   .1980   .5185  -.5185
      2.0600   .3470   .4331  -.4331
      2.0600   .4710   .2936  -.2936
      2.2100  -.4710   .2936  -.2936
      2.2100  -.3470   .4331  -.4331
      2.2100  -.1980   .5185  -.5185
      2.2100   .0000   .5550  -.5550
      2.2100   .1980   .5185  -.5185
      2.2100   .3470   .4331  -.4331
      2.2100   .4710   .2936  -.2936
      2.3600  -.4710   .2936  -.2936
      2.3600  -.3470   .4331  -.4331
      2.3600  -.1980   .5185  -.5185
      2.3600   .0000   .5550  -.5550
      2.3600   .1980   .5185  -.5185
      2.3600   .3470   .4331  -.4331
      2.3600   .4710   .2936  -.2936
      2.5100  -.4710   .2936  -.2936
      2.5100  -.3470   .4331  -.4331
      2.5100  -.1980   .5185  -.5185
```

2.5100	.0000	.5550	-.5550
2.5100	.1980	.5185	-.5185
2.5100	.3470	.4331	-.4331
2.5100	.4710	.2936	-.2936
2.6442	-.5000	.3500	-.3900
2.6442	-.3700	.3903	-.4900
2.6442	-.2000	.4393	-.5124
2.6442	.0000	.4778	-.5173
2.6442	.1980	.4999	-.5134
2.6442	.3470	.4500	-.4500
2.6442	.4710	.3500	-.3500
2.7783	-.5500	.2657	-.4000
2.7783	-.4000	.3180	-.4570
2.7783	-.2200	.3738	-.4606
2.7783	-.0200	.4205	-.4595
2.7783	.1980	.4545	-.4504
2.7783	.3470	.4200	-.4200
2.7783	.4710	.3500	-.3500
2.9125	-.8500	.0854	-.4261
2.9125	-.5500	.2067	-.4225
2.9125	-.3000	.2930	-.4170
2.9125	-.0500	.3636	-.4075
2.9125	.1980	.4114	-.3903
2.9125	.3470	.3900	-.3763
2.9125	.4710	.3563	-.3563
3.0467	-1.1500	-.1056	-.4278
3.0467	-.7000	.0975	-.4069
3.0467	-.3800	.2155	-.3856
3.0467	-.1000	.3418	-.3508
3.0467	.1980	.3707	-.3331
3.0467	.3411	.3958	-.3154
3.0467	.4710	.4061	-.2919
3.2144	-1.3600	-.2803	-.4437
3.2144	-.8000	-.0034	-.4000
3.2144	-.5000	.1149	-.3639
3.2144	-.1500	.2753	-.2987
3.2144	.1980	.3240	-.2668
3.2144	.4000	.3615	-.2303
3.2144	.6000	.3875	-.1879
3.3821	-1.4800	-.4043	-.4674
3.3821	-.9904	-.1343	-.4225
3.3821	-.6000	.0257	-.3563
3.3821	-.1944	.1714	-.2836
3.3821	.1980	.2811	-.2049
3.3821	.5000	.3428	-.1342
3.3821	1.0500	.3999	.0237
3.5163	-1.5181	-.4579	-.4864
3.5163	-1.0800	-.2062	-.4406

3.5163	-.6500	-.0231	-.3566
3.5163	-.2100	.1372	-.2627
3.5163	.1980	.2568	-.1670
3.5163	.5970	.3448	-.0599
3.5163	1.0500	.4026	.0827
3.5163	1.4500	.4223	.2245
3.6840	-1.5134	-.4798	-.5059
3.6840	-1.0837	-.2286	-.4505
3.6840	-.6561	-.0437	-.3553
3.6840	-.2277	.1152	-.2510
3.6840	.1993	.2464	-.1379
3.6840	.6268	.3444	-.0081
3.6840	1.0547	.4105	.1382
3.6840	1.4830	.4524	.2988
3.6840	1.9116	.4732	.4686
4.1348	-1.5051	-.5361	-.5583
4.1348	-1.0778	-.2817	-.4752
4.1348	-.6528	-.0898	-.3526
4.1348	-.2238	.0769	-.2205
4.1348	.1990	.2189	-.0790
4.1348	.6243	.3349	.0770
4.1348	1.0501	.4295	.2436
4.1348	1.4762	.5129	.4161
4.1348	1.9024	.5925	.5878
4.5857	-1.5061	-.5896	-.6108
4.5857	-1.0804	-.3317	-.5032
4.5857	-.6564	-.1311	-.3631
4.5857	-.2342	.0459	-.2136
4.5857	.1909	.2005	-.0557
4.5857	.6151	.3321	.1136
4.5857	1.0396	.4472	.2906
4.5857	1.4643	.5510	.4703
4.5857	1.8890	.6503	.6453
5.0365	-1.5247	-.6423	-.6633
5.0365	-1.1000	-.3805	-.5346
5.0365	-.6768	-.1708	-.3794
5.0365	-.2564	.0176	-.2165
5.0365	.1686	.1858	-.0474
5.0365	.5919	.3326	.1303
5.0365	1.0155	.4624	.3142
5.0365	1.4392	.5795	.5005
5.0365	1.8629	.6869	.6818
5.4874	-1.5454	-.6939	-.7158
5.4874	-1.1227	-.4285	-.5659
5.4874	-.7013	-.2101	-.3956
5.4874	-.2798	-.0109	-.2209
5.4874	.1417	.1702	-.0422
5.4874	.5632	.3319	.1426

5.4874	.9849	.4755	.3326
5.4874	1.4069	.6038	.5253
5.4874	1.8290	.7194	.7144
5.9382	-1.5606	-.7423	-.7646
5.9382	-1.1425	-.4752	-.5953
5.9382	-.7253	-.2497	-.4123
5.9382	-.3043	-.0419	-.2274
5.9382	.1086	.1491	-.0404
5.9382	.5253	.3246	.1503
5.9382	.9424	.4837	.3455
5.9382	1.3598	.6248	.5450
5.9382	1.7774	.7486	.7436
6.3891	-1.5638	-.7846	-.8051
6.3891	-1.1520	-.5163	-.6217
6.3891	-.7409	-.2864	-.4279
6.3891	-.3267	-.0718	-.2332
6.3891	.0809	.1292	-.0379
6.3891	.4915	.3177	.1590
6.3891	.9024	.4911	.3597
6.3891	1.3135	.6461	.5660
6.3891	1.7250	.7786	.7736
6.8399	-1.5432	-.8197	-.8376
6.8399	-1.1378	-.5475	-.6424
6.8399	-.7335	-.3135	-.4389
6.8399	-.3340	-.0919	-.2346
6.8399	.0765	.1204	-.0307
6.8399	.4818	.3198	.1740
6.8399	.8868	.5038	.3819
6.8399	1.2920	.6701	.5948
6.8399	1.6974	.8137	.8087
7.2907	-1.5205	-.8496	-.8656
7.2907	-1.1210	-.5724	-.6602
7.2907	-.7223	-.3311	-.4475
7.2907	-.3247	-.1025	-.2344
7.2907	.0755	.1159	-.0215
7.2907	.4745	.3233	.1916
7.2907	.8734	.5173	.4073
7.2907	1.2725	.6951	.6267
7.2907	1.6718	.8511	.8461
7.7416	-1.4976	-.8767	-.8911
7.7416	-1.1041	-.5953	-.6769
7.7416	-.7113	-.3477	-.4562
7.7416	-.3184	-.1126	-.2352
7.7416	.0746	.1125	-.0142
7.7416	.4673	.3273	.2066
7.7416	.8602	.5301	.4294
7.7416	1.2532	.7182	.6554
7.7416	1.6464	.8855	.8805

8.1924	-1.4747	-.9020	-.9153
8.1924	-1.0872	-.6175	-.6933
8.1924	-.7004	-.3643	-.4650
8.1924	-.3135	-.1229	-.2367
8.1924	.0739	.1093	-.0080
8.1924	.4603	.3315	.2200
8.1924	.8471	.5425	.4497
8.1924	1.2341	.7399	.6823
8.1924	1.6213	.9182	.9132
8.6433	-1.4509	-.9259	-.9382
8.6433	-1.0698	-.6387	-.7092
8.6433	-.6892	-.3804	-.4740
8.6433	-.3086	-.1331	-.2388
8.6433	.0716	.1055	-.0041
8.6433	.4525	.3353	.2315
8.6433	.8331	.5547	.4684
8.6433	1.2139	.7609	.7080
8.6433	1.5948	.9503	.9453
9.0941	-1.4196	-.9456	-.9570
9.0941	-1.0472	-.6572	-.7236
9.0941	-.6753	-.3952	-.4834
9.0941	-.3034	-.1430	-.2430
9.0941	.0679	.1013	-.0020
9.0941	.4402	.3380	.2400
9.0941	.8121	.5649	.4836
9.0941	1.1842	.7800	.7301
9.0941	1.5564	.9800	.9750
9.5449	-1.3843	-.9627	-.9732
9.5449	-1.0219	-.6740	-.7370
9.5449	-.6599	-.4090	-.4928
9.5449	-.2979	-.1525	-.2470
9.5449	.0642	.0972	-.0006
9.5449	.4262	.3400	.2468
9.5449	.7882	.5741	.4967
9.5449	1.1503	.7978	.7500
9.5449	1.5126	1.0082	1.0032
9.9958	-1.3398	-.9681	-.9779
9.9958	-.9893	-.6816	-.7413
9.9958	-.6394	-.4165	-.4958
9.9958	-.2894	-.1587	-.2481
9.9958	.0608	.0933	.0007
9.9958	.4107	.3392	.2507
9.9958	.7607	.5774	.5038
9.9958	1.1108	.8064	.7608
9.9958	1.4611	1.0239	1.0189
10.4466	-1.2872	-.9635	-.9728
10.4466	-.9507	-.6814	-.7380
10.4466	-.6147	-.4186	-.4939

```
     10.4466  -.2786  -.1620  -.2473
     10.4466   .0574   .0894   .0012
     10.4466   .3935   .3357   .2515
     10.4466   .7295   .5752   .5052
     10.4466  1.0657   .8066   .7632
     10.4466  1.4021  1.0281  1.0231
     10.8975 -1.2174  -.9406  -.9493
     10.8975  -.8997  -.6678  -.7211
     10.8975  -.5823  -.4122  -.4832
     10.8975  -.2649  -.1620  -.2424
     10.8975   .0524   .0838  -.0000
     10.8975   .3698   .3252   .2456
     10.8975   .6872   .5608   .4944
     10.8975  1.0047   .7892   .7480
     10.8975  1.3224  1.0094  1.0044
     11.3483 -1.1223  -.8913  -.8992
     11.3483  -.8301  -.6348  -.6843
     11.3483  -.5383  -.3936  -.4595
     11.3483  -.2465  -.1570  -.2316
     11.3483   .0454   .0759  -.0018
     11.3483   .3372   .3048   .2309
     11.3483   .6291   .5288   .4671
     11.3483   .9210   .7467   .7082
     11.3483  1.2131   .9578   .9528
     11.7992  -.9797  -.8011  -.8079
     11.7992  -.7252  -.5724  -.6159
     11.7992  -.4711  -.3564  -.4145
     11.7992  -.2170  -.1441  -.2099
     11.7992   .0372   .0653  -.0031
     11.7992   .2913   .2714   .2060
     11.7992   .5455   .4735   .4188
     11.7992   .7997   .6705   .6364
     11.7992  1.0541   .8627   .8577
     12.2500  -.4519  -.3784  -.3834
     12.2500  -.3347  -.2716  -.2920
     12.2500  -.2176  -.1696  -.1967
     12.2500  -.1005  -.0691  -.0999
     12.2500   .0166   .0301  -.0020
     12.2500   .1337   .1279   .0972
     12.2500   .2508   .2239   .1983
     12.2500   .3679   .3175   .3015
9-   12.2500   .4851   .4107   .4057
11-       .0000      .0000      .0000  100.0000      .0000  100.0000
11- T300 EPOX        .0050      .0000     .6000   -45.0000
11-       .0000      .0000      .0000  100.0000      .0000  100.0000
11- T300 EPOX        .0050      .0000     .6000    45.0000
11-       .0000      .0000      .0000  100.0000      .0000  100.0000
11- T300 EPOX        .0050      .0000     .6000      .0000
```

```
11-       0.0       0.0       20.0      80.0      15.0      85.0
11- BOR5 ALT6       .0070     .0000     .7000     10.7
11-       .0000     .0000     .0000  100.0000     .0000  100.0000
11- T300 EPOX       .0080     .0000     .6000     .0000
13-  111
13-    4   4   4   3   3   2   3   3   3   3   1   3   3   3   3   2   3   3   3   1
13-    3   3   3   2   3   3   3   1   3   3   3   2   3   3   3   1   3   3   3   3
13-    3   3   3   3   3   3   3   3   3   3   3   3   3   3   3   3   3   3   3   3
13-    3   3   3   3   3   3   3   3   3   3   3   3   3   3   3   3   3   3   3   3
13-    3   3   3   3   3   3   3   3   3   3   3   3   3   3   3   3   3   3   3   3
13-    3   3   3   3   3   3   5   5   5   5   5
```

DATABANK

```
         1         2         3         4         5         6         7         8
1........0.........0.........0.........0.........0.........0.........0.........0


 2
T300 ANIS 10-26-79 NO REF.
  3000 .0003
 1
0.0         .064      32000000. 2000000.   .20       .25       1300000.  700000.
-.00000055 .0000056  580.       58.        .17       350000.   300000.   0.0
0.0         0.0       0.0
BOR5 ISO  04-11-74 NO REF.
     1 .0056
 1
 0.0        .095      58000000. 58000000. .2        .2        24200000. 24200000.
 .0000028   .0000028  223.      223.      .310      600000.   700000.   100000.
 200000.    100000.   100000.
 2
EPOX ISO  10-26-79 NO REF.
 1
 0.0        .0443     500000.   .41       .000057   1.25      .25       .225
 15000.     21000.    7000.     .014      .042      .032      .038
ALT6      11-07-73
 1
 0.0        .095      10000000. .33       .0000129  104.0     .23       .225
 52000.     52000.    26000.    .0052     .0052     .00905    .00905
 2
T300/EPOX 10-26-79
 1.0        4.0       1.0       2.0       1.0       4.0
 1.0        2.0       1.0       1.0       1.05      1.05
 1.0        .16       1.0       1.0       .70       .70
 1.37       .80       13.3      31900.    16.5      .70
 1.0        1.0       1.0       1.0       1.0
BOR5/ALT6 01-25-77
 1.0        4.0       1.0       2.0       1.0       4.0
 1.0        2.0       1.0       1.0       1.0       1.0
 .56        1.0       1.0       1.0       .313      .343
 .462       .30       8.33      52000.    2.92      1.0
 1.0        1.0       1.0       1.0       1.0
```

NASTRAN Deck

```
NASTRAN FILES=PLT2
ID   DEMO NO. 2
APP  DISP
SOL   1
TIME 60
CEND
TITLE =  GRAPHITE/EPOXY TURBOPROP BLADE WITH BORON/ALUMINUM INLAYS
  SUBTITLE = ROTOR SPEED 8500 RPM
      SPC = 25
      DISP = ALL
      FORCE = ALL
      SPCF = ALL
      STRESS(PRINT,PUNCH) = ALL
      LOAD = 8500
   OUTPUT(PLOT)
      PLOTTER NASTPLT T,0
      SET 1 = ALL
      AXES MZ,Y,X
      VIEW 0.0,0.0,0.0
      FIND SCALE  ORIGIN 1  SET 1
   PLOT
      AXES X,Y,Z
      VIEW 0.0,0.0,0.0
      FIND SCALE ORIGIN 2  SET 1
   PLOT
BEGIN BULK
PARAM   GRDPNT  0
RFORCE      8500       0       141.667    0.        1.   .022
SPC1    25      13456   1       THRU    9
SPC1    25      6       8       THRU    21
SPC     25      5       123456
EIGR,99,INV,1.0,600.0,3,,,,+E99
+E99,MAX
FORCE,50,271, ,10.0,0.0,0.0,1.0
FORCE,50,272, ,20.0,0.0,0.0,1.0
FORCE,50,273, ,20.0,0.0,0.0,1.0
FORCE,50,274, ,20.0,0.0,0.0,1.0
FORCE,50,275, ,20.0,0.0,0.0,1.0
FORCE,50,276, ,20.0,0.0,0.0,1.0
FORCE,50,277, ,20.0,0.0,0.0,1.0
FORCE,50,278, ,20.0,0.0,0.0,1.0
FORCE,50,279, ,10.0,0.0,0.0,1.0
```

POSTPROCESSOR DECK

CARD GROUP DESIGNATION

```
         1         2         3         4         5         6         7         8
1........0.........0.........0.........0.........0.........0.........0.........0

1- TITLE= DEMONSTRATION PROBLEM NO. 2
1- TITLE= GRAPH/EPOXY TURBOPROP BLADE WITH
1- TITLE= SURFACE INLAYS OF BORON ALUMINUM
2- POSTPROCESSOR
2- SOLID BLADE
3- ENDOPTIONS
4-    0   0   0
6-  160 168
```

CARD GROUP 2

Two option cards are used in this postprocessing deck. POSTPROCESSING and SOLID specify that postprocessing of two-dimensional stress output from a structure modeled using the SOLID blade format.

CARD GROUP 3

Required ENDOPTIONS card.

CARD GROUP 4

The three integer values on this card are KSMF, NXSECT and NSPAR. KSMF is used to select the method for calculating the strain magnification factor which will be used in establishing the limiting stress values for each ply layer in each node. Setting KSMF = 0 selects the default value which is recommended. The other integers are for the SHELL/SPAR option and may be neglected for this problem because the SOLID option is selected in Card Group 2.

CARD GROUP 6

Because the option PRTOUT was not selected in CARD GROUP 2 the user may select up to 10 grid point sequential sets for postprocessing output. For this problem grid points 160 thru 168 were selected. If no output is desired a blank record must be provided.

PLOT OF DEMO NO.2

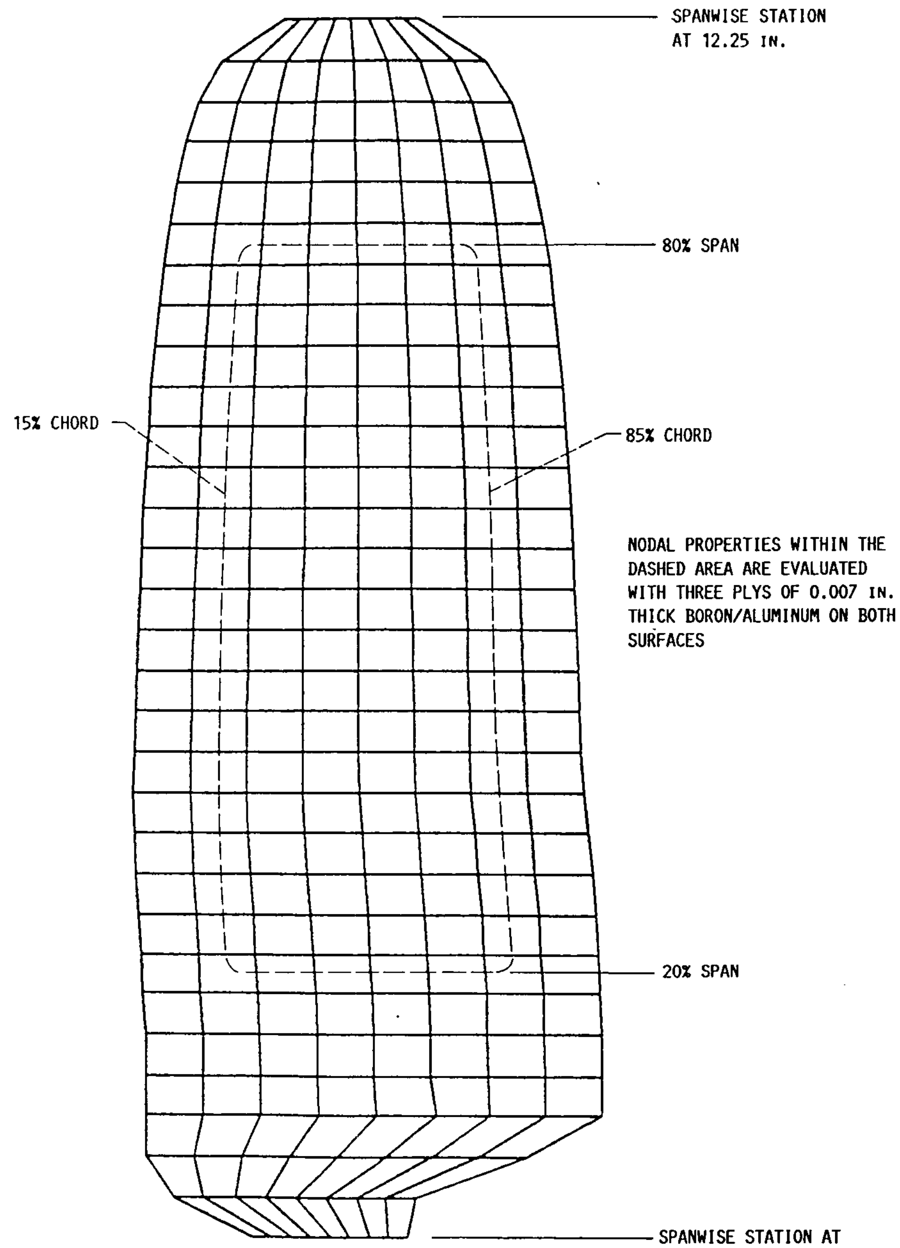


FIGURE 2. - DEMONSTRATION PROBLEM NUMBER 2, GRAPHITE/EPOXY TURBOPROP BLADE WITH SURFACE INLAYS OF BORON/ALUMINUM.

PROBLEM NO. 3

This problem is similar to PROBLEM NO. 1 except the user has composite ply properties available for use in the analysis. However, COBSTRAN is designed to always use constituent fiber and matrix properties and use the micromechanics module to generate ply properties. An algorithm is provided in COBSTRAN to extract approximate fiber and matrix properties corresponding to user supplied composite ply properties. To use this algorithm, a specific matrix designated 'SPOX' and a fiber designated 'T300'must be specified from the internal databank. See Section 3, PROPERTY INPUT, of the USER'S MANUAL for more details.

PREPROCESSOR DECK DESCRIPTION

CARD GROUP 2

These are the program options for this COBSTRAN problem. Each option is described in detail in the COBSTRAN USER'S MANUAL. For this case the preprocessor is called to generate a mesh of one element thru-the-thickness. An echo of the input data and a full printout is requested for output. A COSMIC NASTRAN bulk data deck will be generated for the model and the user will specify the ply layup order to be used to calculate material properties. Selection of the PROPERTIES option indicates that the user will supply ply properties for some or all ply layers and CARD GROUP 15 is activated. Selection of the PRESSURE LOAD option indicates that the pressures on the grid point input records will be interpolated over the blade surface and NASTRAN PLOAD cards will be generated for the model.

CARD GROUP 3

Required ENDOPTIONS card.

CARD GROUP 4

Anisotropic material properties generated for each node are to be based on reduced bending properties and are requested by IMAT = 2. The number of material systems(plys) to be described in Card Group 11 of this input deck are designated by NDES = 3.

CARD GROUP 5

Node number 8 is designated for detailed output of ply properties as indicated by NOPLY = 8. Forty two ply properties will be printed for each ply layer at this grid point. Three cross sections will be used to define the plate and this is indicated by NSECT = 3.

CARD GROUP 6

The form of the grid point input indicated by IGRD = 1 is (X Y ZU ZL TU TL PU PL). The number of sections desired for output is indicated by IU = 15 and the number of nodes output per chord is indicated by JU = 5. Quadrilateral elements are requested by MESH = 4.

CARD GROUP 7

Each of the three chordwise sections will be defined by two grid definitions.

CARD GROUP 8

The blade will be interpolated/extrapolated spanwise between the two span dimensions specified by XBEG = 0.0 and XEND = 10.5.

CARD GROUP 9

Input for three chordwise sections is provided in the form specified by IGRD = 1 (CARD GROUP 6). Pressure is indicated on the surface but PLOAD cards will not be generated because no PRESSURE option is indicated.

CARD GROUP 11

Three composite layers are specified. Each ply is represented by two physical records.

The first record defines the location of the ply on the blade by percent of thickness, span and chord. The first two values on this record refer to the initial and final percent thickness of the thickest grid point of the blade. The thickness calculated from the difference in these values divided by the ply thickness will determine the maximum number of layers of this particular ply at all other grid points, not to exceed the actual thickness at each grid point. The next two values are the initial and final percent span and the last two are initial and final percent chord as shown in Figure 10 of the USER'S MANUAL.

Note: Initial and final percent thicknesses are ignored when the PLYORDER option is specified.

The second record specifies fiber type, matrix type, ply thickness, void volume ratio, fiber volume ratio and orientation angle in degrees relative to the structural x-axis as shown in Figure 6 of the USER'S MANUAL.

CARD GROUP 13

The ply stack-up order for half-thickness is designated by 38 plys starting at the outer surface. Only the number of plys needed to fill the thickness will be used. If an insufficient number of plys is available an ERROR message will be printed. The ply designation numbers correspond to the order in which the plys are listed in CARD GROUP 11.

CARD GROUP 15

The number of plys for which properties will be supplied is indicated by the first record in this card group. Each set of properties is defined by two records. The integer value is the ply designation number followed by 13 properties as explained in the USER'S MANUAL.

PREPROCESSOR DECK

CARD GROUP DESIGNATION

```
          1         2         3         4         5         6         7         8
 1........0.........0.........0.........0.........0.........0.........0.........0

1- TITLE= DEMONSTRATION PROBLEM NO. 3
1- TITLE= CANTILEVER BEAM WITH USER-SUPPLIED SPECIAL PLY PROPERTIES
2-     PREPROCESSING
2-     PLYORDER SPECIFIED
2-     SOLID BLADE
2-     ECHO
2-     PROPERTIES INPUT
2-     PRTOUT DESIRED
2-     PRESSURE LOAD
2-     COSMIC NASTRAN
3- ENDOPTIONS
4-    2   3
5-    8   3
6-    1  15   5   4
7-    2   2   2
8-   0.0     10.5
9-   0.0     -1.5      .075    -.075                        0.0      10.0
9-   0.0      1.5      .075    -.075                        0.0      10.0
9-   5.0     -1.5      .075    -.075                        0.0      10.0
9-   5.0      1.5      .075    -.075                        0.0      10.0
9-  10.0     -1.5      .075    -.075                        0.0      10.0
9-  10.0      1.5      .075    -.075                        0.0      10.0
11-    0.0    100.0     0.0       100.0     0.0       100.0
11- T300 SPOX  .005      0.0       .60      -45.0
11-    0.0    100.0     0.0       100.0     0.0       100.0
11- T300 SPOX  .005      0.0       .60      +45.0
11-    0.0    100.0     0.0       100.0     0.0       100.0
11- T300 SPOX  .005      0.0       .60        0.0
13-   38
13-    1   2   3   2   3   2   3   2   3   2   3   2   3   2   3   2   3   2   3   2
13-    3   2   3   2   3   2   3   2   3   2   3   2   3   2   3   2   3   2
15-    3
15-    3          .55E+00   .56E-01  23.5E+06   1.5E+06  .800E+06   .25E+00
15-   235.E+03  137.E+03  13.5E+03   40.E+03    8.E+03   4.3E-08   2.3E-05
15-    1          .65E+00   .56E-01  23.5E+06   1.5E+06  .800E+06   .25E+00
15-   235.E+03  137.E+03  13.5E+03   40.E+03    8.E+03   4.3E-08   2.3E-05
15-    2          .60E+00   .56E-01  23.5E+06   1.5E+06  .800E+06   .25E+00
15-   235.E+03  137.E+03  13.5E+03   40.E+03    8.E+03   4.3E-08   2.3E-05
```

DATABANK

```
        1         2         3         4         5         6         7         8
1.......0.........0.........0.........0.........0.........0.........0.........0

 1
T300 ANIS 10-26-79 NO REF.
  3000 .0003
 1
0.0         .064       32000000.  2000000.   .20        .25       1300000.   700000.
-.00000055 .0000056   580.       58.        .17        350000.   300000.    0.0
0.0         0.0        0.0
 1
SPOX ISO  9-26-80  FOR COMPOSITE PROPERTY INPUT BY USER
 1
 0.0        .0443      500000.   .41        .000057   1.25        .25        .225
 15000.     21000.     7000.     .014       .042      .032        .038
 1
T300/SPOX 9-26-80  FOR COMPOSITE PROPERTY INPUT BY USER
 1.0        4.0        1.0       2.0        1.0       4.0
 1.0        2.0        1.0       1.0        1.05      1.05
 1.0        .16        1.0       1.0        .70       .70
 1.37       .80        13.3      31900.     16.5      .70
 1.0        1.0        1.0       1.0        1.0
```

NASTRAN Deck

```
ID   DEMO NO. 3
APP  DISP
SOL  1
TIME 60
CEND
TITLE = CANTILEVER TEST BEAM
      SPC = 25
      DISP = ALL
      FORCE = ALL
      SPCF = ALL
      STRESS(PRINT,PUNCH) = ALL
      LOAD = 4
BEGIN BULK
SPC       25       1      13456
SPC       25       2      13456
SPC       25       3      123456
SPC       25       4      13456
SPC       25       5      13456
GRDSET                                                     6
```

POSTPROCESSOR DECK

```
 CARD GROUP DESIGNATION
 ___________________
|
|          1         2         3         4         5         6         7         8
|  1........0.........0.........0.........0.........0.........0.........0.........0
|
1- TITLE= DEMONSTRATION PROBLEM NO. 3
1- TITLE= CANTILEVERED PLATE
2- POSTPROCESSING
2- SOLID BLADE
3- ENDOPTIONS
4-    0   0   0
6-    1  10
```

CARD GROUP 2

Two option cards are used in this postprocessing deck. POSTPROCESSING and SOLID specify that postprocessing of two-dimensional stress output from a structure modeled using the SOLID blade format.

CARD GROUP 3

Required ENDOPTIONS card.

CARD GROUP 4

The three integer values on this card are KSMF, NXSECT and NSPAR. KSMF is used to select the method for calculating the strain magnification factor which will be used in establishing the limiting stress values for each ply layer in each node. Setting KSMF = 0 selects the default value which is recommended. The other integers are for the SHELL/SPAR option and may be neglected for this problem because the SOLID option is selected in Card Group 2.

CARD GROUP 6

Because the option PRTOUT was not selected in CARD GROUP 2 the user may select up to 10 grid point sequential sets for postprocessing output. For this problem only grid points 1 thru 10 were selected. If no output is desired a blank record must be provided.

PLOT OF DEMO NO. 3

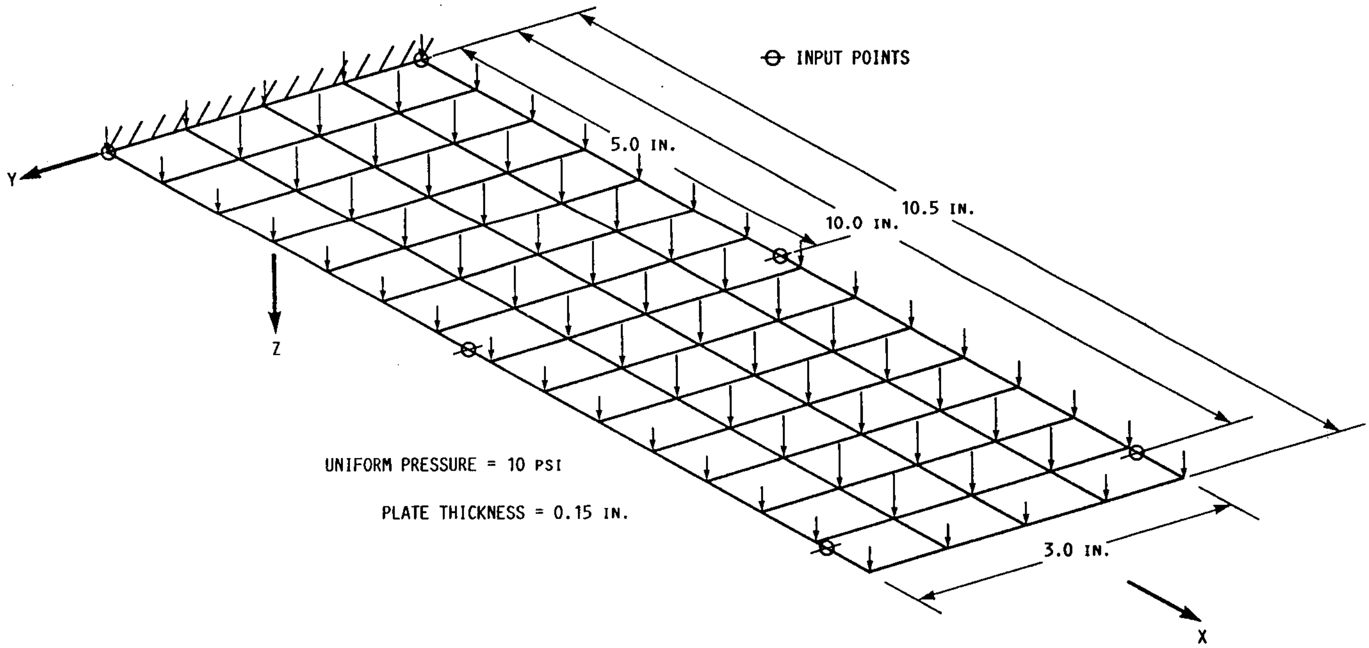


FIGURE 3. - DEMONSTRATION PROBLEM NUMBER 3, FLAT PLATE WITH USER-SUPPLIED PLY PROPERTIES AND UNIFORM PRESSURE LOAD.

PROBLEM NO. 4

This example demonstrates the basic characteristics of the datasets required to implement the COBSTRAN code for an isotropic material and the free-field input format option.

This flat plate with sweep and twist is loaded by a centrifugal force. The user is encouraged to modify this problem by changing sweep, twist and mesh size to demonstrate the interpolating capabilities within the code and the ease with which a complex shape can be modeled.

PREPROCESSOR DECK DESCRIPTION

CARD GROUP 2

These are the program options for this COBSTRAN problem. Each option is described in detail in the COBSTRAN USER'S MANUAL. For this case the preprocessor is called generating a mesh of one element thru-the-thickness. Full printout is requested along with an echo of the input data. An MSC/NASTRAN bulk data deck will be generated for the model.

CARD GROUP 3

Required ENDOPTIONS card.

CARD GROUPS 4 thru 8

The selection of the EZREAD option modifies the input format for these card groups. A neumonic form as shown in this problem is required. The user is cautioned to check the input summary carefully because of the recent development of this feature in COBSTRAN. All values not designated are set to zero.

NOTE: This input must end with an ENDPARAMS card.

CARD GROUP 9

Selection of the EZREAD option enables the FORTRAN 77 free-field format for all input data following the ENDPARAMS card. If the format designated in the USER'S MANUAL will not be filled with data the line must end with a slash. Also, all alphaneumerics must be in quotes. The selection of IGRD = 4 for this problem indicates that the grid point input is of the form
(X Y Z TB TU TL PU PL).

CARD GROUP 16

Values for the isotropic material properties are designated in this card group. The selection of IMAT=4 designates that the six values in this card group are Young's Modulus, shear modulus, Poisson's ratio, mass density, thermal expansion coefficient and thermal expansion reference temperature. A NASTRAN MAT1 card will be generated.

PREPROCESSOR DECK

```
 CARD GROUP DESIGNATION
 |
 |          1         2         3         4         5         6         7         8
 |  1........0.........0.........0.........0.........0.........0.........0.........0
 |
 1- TITLE= DEMONSTRATION PROBLEM NO. 4
 1- TITLE= FLAT PLATE WITH SWEEP AND TWIST
 1- TITLE= ISOTROPIC MATERIAL
 2-    PREPROCESSOR
 2-    SOLID BLADE
 2-    EZREAD
 2-    ECHO
 2-    PRTOUT DESIRED
 2-    MSC NASTRAN
 3- ENDOPTIONS
 +     IMAT = 4
 +     NSECT = 3
 +     IGRD = 4
 4     IUXX = 12
thru   JUYY = 7
 8     MESH = 2
 +     XBEG = 5.00
 +     XEND = 16.50
 +     MSECT = 3 3 3
 + ENDPARAMS
 9-  5.00   -1.477  0.20    0.15/
 9-  5.00    0.0    0.0     0.15/
 9-  5.00    1.477  -.20    0.16/
 9- 11.00   -0.264  .80     0.13/
 9- 11.00    1.2    .10     0.13/
 9- 11.00    2.136  -.70    0.11/
 9- 16.00   1.890   1.4     0.08/
 9- 16.00   2.45    0.2     0.08/
 9- 16.00   3.010   -1.0    0.08/
16- 1.04E+07,4.10E+06,0.00,2.59E-04,0.00,0.00,0.00,0.00,0.00,0.00
```

NASTRAN Deck

```
ID  DEMO NO. 4
APP DISP
SOL 24
TIME 60
CEND
TITLE = FLAT PLATE, SWEEP, TWIST
LABEL = ROTOR SPEED  4000 RPM
      SPC = 10
      LOAD = 1
      DISP = ALL
      SPCFORCE = ALL
      FORCE = ALL
      STRESS = ALL
   OUTPUT(PLOT)
      SET 1 = ALL
      AXES MZ,Y,X
      VIEW 0.0,0.0,30.0
      FIND SCALE  ORIGIN 1  SET 1
   PLOT  ORIGIN 1  SET 1
BEGIN BULK
RFORCE        1                 66.67     0.        1.     0.
SPC1    10      13456    1      THRU      7
SPC     10      4        123456
```

PLOT OF DEMO NO. 4

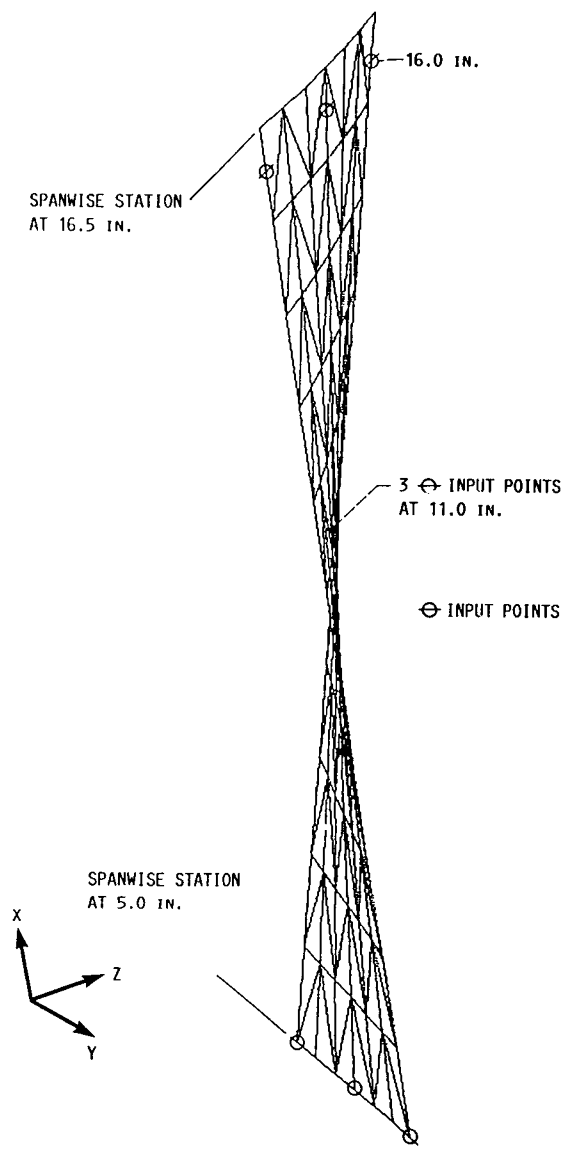


FIGURE 4. - DEMONSTRATION PROBLEM NUMBER 4, SWEPT, TWISTED PLATE WITH ISOTROPIC MATERIAL. 84 GRID POINTS, 132 ELEMENTS.

PROBLEM NO. 5

This example demonstrates the basic characteristics of the datasets required to generate a COBSTRAN model of a wing structure with two spars oriented normal to the midchord line.

This model represents a wind turbine type blade which is mounted at an angle out of the plane of rotation. COBSTRAN will be used to create the model in a local blade coordinate system and the CONE ANGLE option will be used to transform the coordinates to a rotational coordinate system in which the y-axis is the axis of rotation and the x-axis and z-axis lie in the plane of rotation.

PREPROCESSOR DECK DESCRIPTION

CARD GROUP 2

These are the program options for this COBSTRAN problem. Each option is described in detail in the COBSTRAN USER'S MANUAL. Full printout is requested along with an echo of the input data. A COSMIC NASTRAN bulk data deck will be generated for the model and the user will specify the ply layup order to be used to calculate material properties. The SHELL/SPAR option will use this alternate modeling feature to generate an airfoil shell model with internal spars. NASTRAN PLOAD cards will be generated and the final model coordinates will be transformed according to the cone angle specified.

CARD GROUP 3

Required ENDOPTIONS card.

CARD GROUP 4

Anisotropic material properties generated for each node are to be based on reduced membrane properties and are requested by IMAT = 1. The number of material systems(plys) to be described in Card Group 8 of this input deck are designated by NDES = 4.

CARD GROUP 5

Three contiguous spanwise segments of the blade will be created for this model and is designated by NXSECT = 3.

The number of these segments that will contain spars is designated by NXSPAR = 3 and the number of spars by NSPAR = 2. All spars start at the base of the blade and extend through the number of segments specified by NXSPAR.

The number of chordwise spaces into which each cross section will be modeled is designated by NYSPC = 6. Each section is first divided equally into NYSPC spaces. Grid points are then adjusted to accommodate the spar positions. The points between spars, and between spars and leading or trailing edges are then equally spaced. Finally, the space at the leading edge is divided in two to provide a finer mesh on the normally highly curved leading edge. The resulting number of chordwise spaces is NYSPC+1 for the final model.

The value of NOPLY is left blank for this case therefore, extended ply property information will not be printed.

Only one ply material system may be designated for each spar. The array NSPDES(5) is used to indicate the ply designation number for each of the five spars. Two spars are modeled for this blade therefore, the next two integers indicate that ply designation number 4 will be used to model each spar respectively. NSPDES(1)=4 and NSPDES(2)=4. The number of ply layers in the spars is determined by the ply thickness and spar thickness.

CARD GROUP 6

The number of spanwise spaces into which each blade segment will be divided is indicated by NXSPC and the range over which this applies is designated Xi and X(i+1). For this blade the first segment will be divided into 4 spaces between span stations 6.0 and 50.0. The second segment will be divided into 8 spaces between span stations 50.0 and 110.0. The third segment will be divided into 3 spaces between span stations 110.0 and 148.0. For each cross section defined, the spar locations, measured from the leading edge, and the spar thickness is given. Grid points of each section of input in Card Groups 12 & 14. are positioned according to the spar positions defined in this Card Group. Values of the nearest lower Xi are used for each input section of Card Groups 12 & 14. All intermediate positions and thicknesses will be interpolated.

CARD GROUP 7

A full three by three matrix of angles in degrees. For this special case the blade is already defined in the analysis coordinate system and therefore no coordinate transformation will take place. The CONE option is used in this example for information only and should normally not be selected for this problem where its use will cause trivial calculations. See the CONE ANGLE option description in the USER'S MANUAL.

CARD GROUP 8

Four composite layers are specified. Each ply is represented by two physical records.

The first record defines the location of the ply on the blade by percent of thickness, span and chord. The first two values on this record refer to the initial and final percent thickness of the thickest grid point of the blade. The thickness calculated from the difference in these values divided by the ply thickness will determine the maximum number of layers of this particular ply at all other grid points, not to exceed the actual thickness at each grid point. The next two values are the initial and final percent span and the last two are initial and final percent chord as shown in Figure 10 of the USER'S MANUAL.

Note: Initial and final percent thicknesses are ignored when the PLYORDER option is specified.

The second record specifies fiber type, matrix type, ply thickness, void volume ratio, fiber volume ratio and orientation angle in degrees relative to the structural x-axis as shown in Figure 6 of the USER'S MANUAL.

CARD GROUP 9

The ply stack-up order for half-thickness is designated by 5 plys starting at the outer surface. Only the number of plys needed to fill the thickness will be used. If an insufficient number of plys is available an ERROR message will be printed. The ply designation numbers correspond to the order in which the plys are listed in CARD GROUP 8.

CARD GROUP 10

The profile input data is represented by two separate datasets. The first is for the concave/pressure surface of the blade where four sections are defined. The second is for the convex/suction surface of the blade where four sections are defined.

CARD GROUP 11

The number of grid points defining each of the four sections of input data in CARD GROUP 12 for the concave/pressure surface.

CARD GROUP 12

Each grid point defining the concave/pressure surface is designated as X, Y, Z, Thickness, Pressure, Temperature.

CARD GROUP 13

The number of grid points defining each of the four sections of input data in CARD GROUP 14 for the convex/suction surface.

CARD GROUP 14

Each grid point defining the convex/suction surface is designated as X, Y, Z, Thickness, Pressure, Temperature.

PREPROCESSOR DECK

```
 CARD GROUP DESIGNATION
 |
 |          1         2         3         4         5         6         7         8
 |  1.......0.........0.........0.........0.........0.........0.........0.........0
 |
1- TITLE= DEMONSTRATION PROBLEM NO. 5
1- TITLE= SHELL/SPAR TYPE BLADE
1- TITLE= STATIC LOAD CASE
2- PREPROCESSOR
2- ECHO
2- SHELL/SPAR
2- PRESSURE LOAD
2- COSMIC NASTRAN
2- CONE ANGLE
2- PLYORDER SPECIFIED
3- ENDOPTIONS
4-     1    4
5-     3    3    2    6         4    4
6-     4   6.0   9.0  .050  18.0  .050
6-     8  50.0   7.5  .050  15.0  .050
6-     3 110.0   5.0  .040  10.0  .040
6-       148.0
7-    0.0     90.0     90.0     90.0      0.0     90.0     90.0     90.0      0.0
8-                      0.0       100.0     0.0       100.0
8- T300 EPOX  .005      0.0       .60        90.0
8-                      0.0       100.0     0.0       100.0
8- T300 EPOX  .005      0.0       .60       -45.0
8-                      0.0       100.0     0.0       100.0
8- T300 EPOX  .005      0.0       .60       +45.0
8-                      0.0       100.0     0.0       100.0
8- T300 EPOX  .005      0.0       .60        0.0
9-     5
9-     1    2    4    3    4
10-    4    4
11-   11   11    9    7
12-       6.000   -18.000      .000      .050
          6.000   -14.400    -2.700      .050
          6.000   -10.800    -3.600      .050
          6.000    -7.200    -4.124      .050
          6.000    -3.600    -4.409      .050
          6.000     -.000    -4.500      .050
          6.000     3.600    -4.409      .050
          6.000     7.200    -4.124      .050
          6.000    10.800    -3.600      .050
          6.000    14.400    -2.700      .050
```

```
         6.000    18.000     0.0         .050
        54.000   -14.943     1.307       .050
        54.000   -12.150    -1.196       .050
        54.000    -9.227    -2.204       .050
        54.000    -6.277    -2.901       .050
        54.000    -3.309    -3.399       .050
        54.000     -.327    -3.736       .050
        54.000     2.668    -3.922       .050
        54.000     5.678    -3.947       .050
        54.000     8.704    -3.773       .050
        54.000    11.758    -3.287       .050
        54.000    14.943    -1.307       .050
       120.000    -9.659     2.588       .040
       120.000    -7.672      .344       .040
       120.000    -5.390     -.797       .040
       120.000    -3.041    -1.691       .040
       120.000     -.647    -2.415       .040
       120.000     1.788    -2.985       .040
       120.000     4.269    -3.385       .040
       120.000     6.816    -3.538       .040
       120.000     9.659    -2.588       .040
       150.000    -4.330     2.500       .020
       150.000    -3.353      .860       .020
       150.000    -2.033     -.187       .020
       150.000     -.625    -1.083       .020
       150.000      .854    -1.854       .020
       150.000     2.421    -2.474       .020
12-    150.000     4.330    -2.500       .020
13-    11  11    9    7
14-      6.000   -18.000      .000       .050
         6.000   -14.400     2.700       .050  2.5
         6.000   -10.800     3.600       .050  5.0
         6.000    -7.200     4.124       .050  10.0
         6.000    -3.600     4.409       .050  15.0
         6.000     -.000     4.500       .050  20.0
         6.000     3.600     4.409       .050  15.0
         6.000     7.200     4.124       .050  10.0
         6.000    10.800     3.600       .050  5.0
         6.000    14.400     2.700       .050  2.5
         6.000    18.000     0.0         .050
        54.000   -14.943     1.307       .050
        54.000   -11.758     3.287       .050  1.25
        54.000    -8.704     3.773       .050  2.5
        54.000    -5.678     3.947       .050  5.0
        54.000    -2.668     3.922       .050  10.0
        54.000      .327     3.736       .050  15.0
        54.000     3.309     3.399       .050  10.0
        54.000     6.277     2.901       .050  5.0
```

54.000	9.227	2.204	.050	2.5
54.000	12.150	1.196	.050	1.25
54.000	14.943	-1.307	.050	
120.000	-9.659	2.588	.040	
120.000	-6.816	3.538	.040	1.25
120.000	-4.269	3.385	.040	2.5
120.000	-1.788	2.985	.040	5.0
120.000	.647	2.415	.040	10.0
120.000	3.041	1.691	.040	5.0
120.000	5.390	.797	.040	2.5
120.000	7.672	-.344	.040	1.25
120.000	9.659	-2.588	.040	
150.000	-4.330	2.500	.020	
150.000	-2.421	2.474	.020	
150.000	-.854	1.854	.020	
150.000	.625	1.083	.020	
150.000	2.033	.187	.020	
150.000	3.353	-.860	.020	
150.000	4.330	-2.500	.020	

DATABANK

```
         1         2         3         4         5         6         7         8
1........0.........0.........0.........0.........0.........0.........0.........0

 1
T300 ANIS 10-26-79 NO REF.
  3000 .0003
 1
0.0        .064      32000000. 2000000.  .20        .25      1300000.  700000.
-.00000055 .0000056  580.      58.       .17       350000.   300000.   0.0
0.0        0.0       0.0
 1
EPOX ISO  10-26-79 NO REF.
 1
 0.0       .0443     500000.   .41       .000057   1.25      .25       .225
 15000.    21000.    7000.     .014      .042      .032      .038
 1
T300/EPOX 10-26-79
 1.0       4.0       1.0       2.0       1.0       4.0
 1.0       2.0       1.0       1.0       1.05      1.05
 1.0       .16       1.0       1.0       .70       .70
 1.37      .80       13.3      31900.    16.5      .70
 1.0       1.0       1.0       1.0       1.0
```

NASTRAN Deck

```
NASTRAN   FILES=PLT2
ID   DEMO NO. 5
APP  DISP
SOL  1,0
TIME 60
CEND
        SPC = 25
        LOAD = 4
        STRESS(PRINT,PUNCH) = ALL
    OUTPUT(PLOT)
        SET 1 = ALL
        FIND SCALE  ORIGIN 1  SET 1
    PLOT ORIGIN 1  SET 1
        AXES Z,X,Y
        VIEW = 0.0,0.0,0.0
        FIND SCALE  ORIGIN 2  SET 1
    PLOT ORIGIN 2  SET 1
        AXES MX,Y,Z
        VIEW = 0.0,0.0,0.0
        FIND SCALE  ORIGIN 3  SET 1
    PLOT ORIGIN 3  SET 1
BEGIN BULK
RFORCE    10      0               1.0     0.0     1.0     0.0
SPC1      25      123456   1      THRU    14
```

POSTPROCESSOR DECK

CARD GROUP DESIGNATION

```
         1         2         3         4         5         6         7         8
 1.......0.........0.........0.........0.........0.........0.........0.........0

1- TITLE= DEMONSTRATION PROBLEM NO. 5
1- TITLE= SHELL/SPAR TYPE BLADE
1- TITLE= STATIC LOAD CASE
2- POSTPROCESSOR
2- SHELL/SPAR
3- ENDOPTIONS
4-   0   3   2
6-   30  35  40  42
```

CARD GROUP 2

Two option cards are used in this postprocessing deck. POSTPROCESSING and SHELL/SPAR specify that postprocessing of stress output is requested for a structure modeled as an airfoil shell with internal spars.

CARD GROUP 3

Required ENDOPTIONS card.

CARD GROUP 4

The three integer values on this card are KSMF, NXSECT and NSPAR. KSMF is used to select the method for calculating the strain magnification factor which will be used in establishing the limiting stress values for each ply layer in each node. Setting KSMF = 0 selects the default value which is recommended. The other integers are for the SHELL/SPAR option and are a repeat of values from the preprocessor deck.

CARD GROUP 6

Because the option PRTOUT was not selected in CARD GROUP 2 the user may select up to 10 grid point sequential sets for postprocessing output. For this problem two sequential sets were selected. Printed output will be provided for grid points 30 thru 35 and 40 thru 42. If no output is desired a blank record must be provided.

PLOT OF DEMO NO. 5

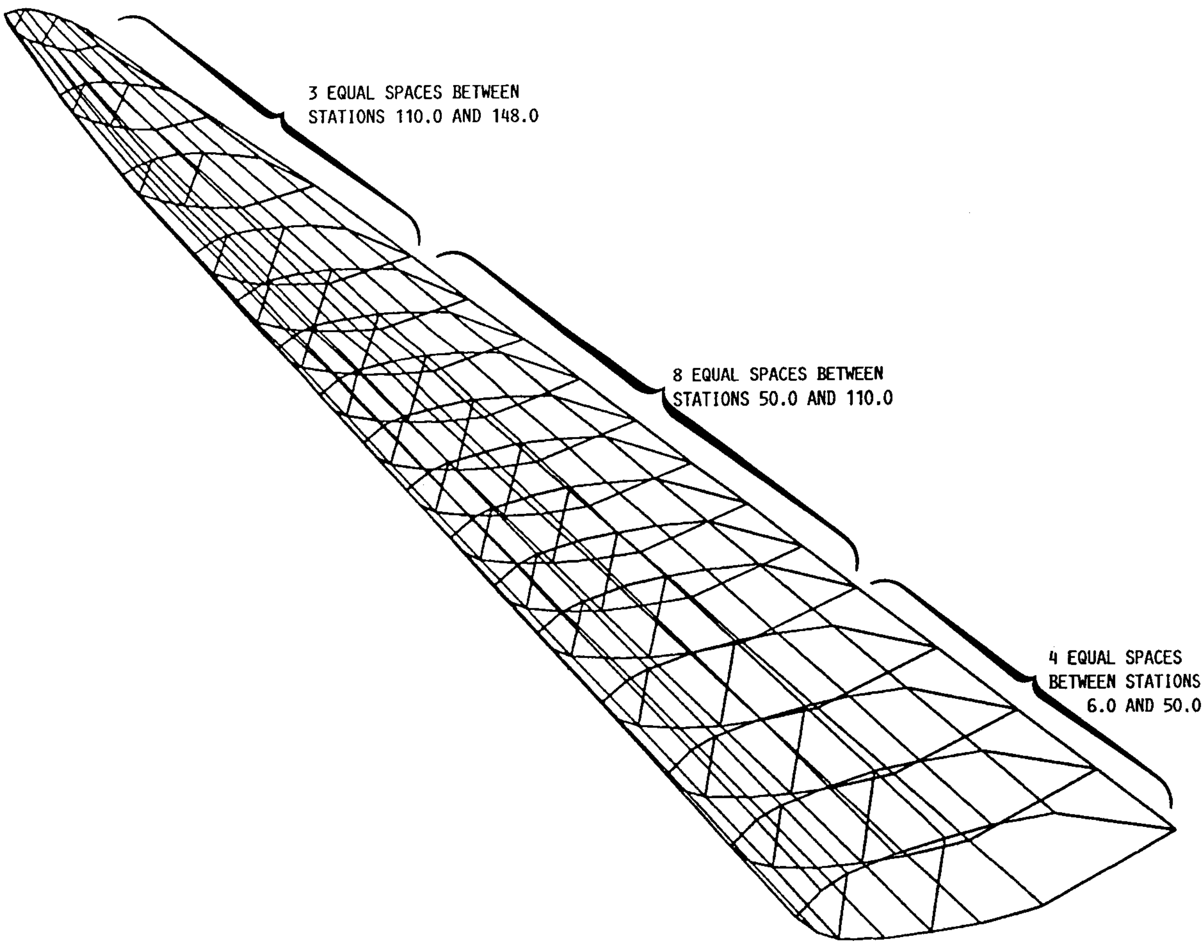


FIGURE 5. - DEMONSTRATION PROBLEM NUMBER 5, WIND GENERATOR BLADE.

PROBLEM NO. 6

This problem demonstrates the input for a wind generator blade which is 62 ft. long with a 4.5 ft chord at the root. The blade is made entirely of fiberglass/epoxy. Its design is a thin (0.078 in.) airfoil shell with two variable thickness spars between stations at 60 inches and 675 inches.

PREPROCESSOR DECK DESCRIPTION

CARD GROUP 2

These are the program options for this COBSTRAN problem. Each option is described in detail in the COBSTRAN USER'S MANUAL. Full printout is requested along with an echo of the input data. A COSMIC NASTRAN bulk data deck will be generated for the model and the user will specify the ply layup order to be used to calculate material properties. The SHELL/SPAR option will use this alternate modeling feature to generate an airfoil shell model with internal spars. NASTRAN PLOAD cards will be generated and the final model coordinates will be transformed according to the cone angle specified. Usually surface coordinates are furnished for airfoil sections. COBSTRAN will transform all grid points to a mid-thickness line throughout the airfoil. Selection of the PROFILE option will suppress this feature and retain grid coordinates on the surface as expected for the input data.

CARD GROUP 3

Required ENDOPTIONS card.

CARD GROUP 4

Anisotropic material properties generated for each node are to be based on reduced membrane properties and are requested by IMAT = 1. The number of material systems(plys) to be described in Card Group 8 of this input deck are designated by NDES = 3.

CARD GROUP 5

Four contiguous spanwise segments of the blade will be created for this model and is designated by NXSECT = 4.

The number of these segments that will contain spars is designated by NXSPAR = 3 and the number of spars by NSPAR = 2. All spars start at the base of the blade and extend through the number of segments specified by NXSPAR.

The number of chordwise spaces into which each cross section will be modeled is designated by NYSPC = 6. Each section is first divided equally into NYSPC spaces. Grid points are then adjusted to accommodate the spar positions. The points between spars, and between spars and leading or trailing edges are then equally spaced. Finally, the space at the leading edge is divided in two to provide a finer mesh on the normally highly curved leading edge. The resulting number of chordwise spaces is NYSPC+1 for the final model.

The value of NOPLY is 25 for this case therefore, extended ply property information will be printed for grid point 25 tabulating forty two properties for each ply layer at this grid point.

Only one ply material system may be designated for each spar. The array NSPDES(5) is used to indicate the ply designation number for each of the five spars. Two spars are modeled for this blade therefore, the next two integers indicate that ply designation number 3 will be used to model each spar respectively. NSPDES(1)=3 and NSPDES(2)=3.

CARD GROUP 6

The number of spanwise spaces into which each blade segment will be divided is indicated by NXSPC and the range over which this applies is designated Xi and X(i+1). For this blade the first segment will be divided into 7 spaces between span stations 60.0 and 200.0. The second segment will be divided into 20 spaces between span stations 200.0 and 500.0. The third segment will be divided into 15 spaces between span stations 500.0 and 675.0. The fourth segment will be divided into 10 spaces between span stations 675.0 and 750.0. For each cross section defined, the spar locations measured from the leading edge, and the spar thickness is given. Grid points of each section of input in Card Groups 12 & 14. are positioned according to the spar positions defined in this Card Group. Values of the nearest lower Xi are used for each input section of Card Groups 12 & 14. All intermediate positions and thicknesses will be interpolated.

CARD GROUP 7

A full three by three matrix of angles in degrees. See the CONE ANGLE option description in the USER'S MANUAL.

CARD GROUP 8

Three composite layers are specified. Each ply is represented by two physical records.

The first record defines the location of the ply on the blade by percent of thickness, span and chord. The first two values on this record refer to the initial and final percent thickness of the thickest grid point of the blade. The thickness calculated from the difference in these values divided by the ply thickness will determine the maximum number of layers of this particular ply at all other grid points, not to exceed the actual thickness at each grid point. The next two values are the initial and final percent span and the last two are initial and final percent chord as shown in Figure 10 of the USER'S MANUAL.

Note: Initial and final percent thicknesses are ignored when the PLYORDER option is specified.

The second record specifies fiber type, matrix type, ply thickness, void volume ratio, fiber volume ratio and orientation angle in degrees relative to the structural x-axis as shown in Figure 6 of the USER'S MANUAL.

CARD GROUP 10

The profile input data is represented by two separate datasets. The first is for the concave/pressure surface of the blade where six sections are defined. The second is for the convex/suction surface of the blade there where six sections are defined.

CARD GROUP 11

The number of grid points defining each of the six sections of input data in CARD GROUP 12 for the concave/pressure surface.

CARD GROUP 12

Each grid point defining the concave/pressure surface is designated as X, Y, Z, Thickness, Pressure, Temperature.

CARD GROUP 13

The number of grid points defining each of the six sections of input data in CARD GROUP 14 for the convex/suction surface.

CARD GROUP 14

Each grid point defining the convex/suction surface is designated as X, Y, Z, Thickness, Pressure, Temperature.

PREPROCESSOR DECK

```
 CARD GROUP DESIGNATION
|
|         1         2         3         4         5         6         7         8
|  1........0.........0.........0.........0.........0.........0.........0.........0
|
1- TITLE= DEMONSTRATION PROBLEM NO. 6
1- TITLE= AIRCRAFT WING STRUCTURE BLADE
1- TITLE= WIND ENERGY STUDIES
2- PREPROCESSING
2- SHELL/SPAR BLADE
2- ECHO
2- PRTOUT DESIRED
2- PROFILE
2- COSMIC NASTRAN
2- CONE ANGLE
3- ENDOPTIONS
4-    1   3
5-    4   3   2   9  25   3   3
6-    7 60.  10.0  .4225  27.0 .26
6-   20 200.  9.0  .3250  26.0 .208
6-   15 500.  8.0  .1105  20.0 .104
6-   10 675.  7.0  .026   15.0 .052
6-      750.
7- 7.0      90.0     83.0     90.0     0.0      90.0     83.0     90.0     7.0
8-  0.0       16.7      0.0       100.0     0.0       100.0
8- SGLA EPOX  .0065     0.0       .65       45.0
8-  16.7      25.2      0.0       100.0     0.0       100.0
8- SGLA EPOX  .0065     0.0       .65       90.0
8-  25.2      50.0      0.0       100.0     0.0       100.0
8- SGLA EPOX  .0065     0.0       .65       0.0
10-   6   6
11-   9   9   9   9   8   7
12- 60.00     -14.0      0.0       .078
    60.00     -13.0     -3.6       .078
    60.00     -10.0     -6.5       .078
    60.00     -5.0      -8.3       .078
    60.00      0.0      -8.5       .078
    60.00      10.0     -7.1       .078
    60.00      20.0     -4.2       .078
    60.00      30.0      .30       .078
    60.00      40.0     5.75       .078
    93.75     -14.0     0.0        .078
    93.75     -13.0     -3.6       .078
    93.75     -10.0     -6.5       .078
    93.75     -5.0      -8.3       .078
```

```
        93.75       0.0        -8.5        .078
        93.75       10.0       -7.1        .078
        93.75       20.0       -4.2        .078
        93.75       30.0       .30         .078
        93.75       40.0       5.75        .078
        187.5      -13.7       0.0         .078
        187.5      -12.0       -3.5        .078
        187.5      -10.0       -4.7        .078
        187.5      -5.0        -5.8        .078
        187.5       0.0        -6.0        .078
        187.5       10.0       -5.0        .078
        187.5       20.0       -2.8        .078
        187.5       30.0       .6          .078
        187.5       40.0       4.6         .078
        357.0      -10.9       -0.7        .078
        357.0      -10.0       -2.0        .078
        357.0      -6.0        -3.3        .078
        357.0      -3.0        -3.6        .078
        357.0       0.0        -3.6        .078
        357.0       10.0       -2.9        .078
        357.0       20.0       1.2         .078
        357.0       30.0       1.3         .078
        357.0       31.0       1.7         .078
        562.0      -7.3        0.0         .078
        562.0      -7.0        - .6        .078
        562.0      -6.0        -1.1        .078
        562.0      -3.0        -1.9        .078
        562.0       0.0        -2.3        .078
        562.0       10.0       -2.0        .078
        562.0       20.0       - .90       .078
        562.0       22.4       - .20       .078
        750.0      -4.2         .0         .078
        750.0      -4.0         -.1        .078
        750.0      -2.0         -.5        .078
        750.0       0.0         -.7        .078
        750.0       4.0        -1.0        .078
        750.0      10.0        -1.1        .078
    12- 750.0      13.5        -1.0        .078
    13-   9    9    9    9    8   7
    14- 60.00      -14.0        0.         .078
        60.00      -13.0        5.0        .078
        60.00      -12.0        7.0        .078
        60.00      -10.0        9.4        .078
        60.00      0.           13.0       .078
        60.00       10.0       13.00       .078
        60.00       20.0       11.30       .078
        60.00       30.0       8.50        .078
        60.00       40.0       5.75        .078
```

93.75	-14.0	0.	.078
93.75	-13.0	5.0	.078
93.75	-12.0	7.0	.078
93.75	-10.0	9.4	.078
93.75	0.	13.0	.078
93.75	10.0	13.00	.078
93.75	20.0	11.30	.078
93.75	30.0	8.50	.078
93.75	40.0	5.75	.078
187.5	-13.7	0.0	.078
187.5	-12.0	4.5	.078
187.5	-10.0	6.6	.078
187.5	-5.0	9.0	.078
187.5	0.	9.8	.078
187.5	10.0	10.0	.078
187.5	20.0	8.0	.078
187.5	30.0	7.0	.078
187.5	40.0	4.6	.078
375.0	-10.9	0.0	.078
375.0	-10.0	1.2	.078
375.0	-6.0	4.8	.078
375.0	-3.0	5.6	.078
375.0	0.0	6.0	.078
375.0	10.0	5.4	.078
375.0	20.0	3.7	.078
375.0	30.0	1.8	.078
375.0	31.0	1.7	.078
562.0	-7.3	0.0	.078
562.0	-7.0	1.70	.078
562.0	-6.0	2.40	.078
562.0	-3.0	3.30	.078
562.0	0.0	3.50	.078
562.0	10.0	2.70	.078
562.0	20.0	.70	.078
562.0	22.4	-.20	.078
750.0	-4.2	.6	.078
750.0	-4.0	.9	.078
750.0	-2.0	1.5	.078
750.0	0.0	1.7	.078
750.0	4.0	1.2	.078
750.0	10.0	.2	.078
750.0	13.5	-1.0	.078

DATABANK

Use the following data as the external databank to default to the internal databank.

```
       1         2         3         4         5         6         7         8
1........0.........0.........0.........0.........0.........0.........0.........0

0
0
0
```

NASTRAN Deck

```
NASTRAN   FILES=PLT2
ID DEMO NO. 6
APP  DISPLACEMENT
SOL  1,0
TIME 90
CEND
TITLE = WINDMILL BLADE STRESS DISTRIBUTION STUDY
      SPC = 2
      DISP = ALL
OUTPUT
      SUBTITLE = LOAD DUE TO GRAVITY AND 40 RPM
   SUBCASE 1
      LABEL = BLADE DOWN
      LOAD = 12
      STRESS(PRINT,PUNCH) = ALL
   SUBCASE 2
      LABEL = BLADE HORIZONTAL  (LEADING EDGE DOWN)
      LOAD = 14
   SUBCASE 3
      LABEL = BLADE HORIZONTAL  (LEADING EDGE UP)
      LOAD = 15
   OUTPUT(PLOT)
      SET 1 = ALL
      AXES X,Y,Z
      VIEW 0.0,0.0,0.0
      FIND SCALE  ORIGIN 1  SET 1
   PLOT  ORIGIN 1  SET 1
      AXES X,Y,Z
      VIEW 30.0,30.0,0.0
      FIND SCALE  ORIGIN 2  SET 1
   PLOT  ORIGIN 2  SET 1
      AXES Z,X,Y
      VIEW 30.0,10.0,0.0
      FIND SCALE  ORIGIN 3  SET 1
   PLOT  ORIGIN 3  SET 1
BEGIN BULK
CORD2R  1       0       0.0     0.0     0.0     0.0     0.0     1.0+5   +C1
+C1     1.0+5   0.0     0.0
LOAD    12      1.0     1.0     11      1.0     2
LOAD    14      1.0     1.0     11      1.0     4
LOAD    15      1.0     1.0     11      1.0     5
GRAV    2               386.4   1.0
GRAV    3               386.4   -1.0
GRAV    4               386.4            -1.0
```

```
GRAV    5               386.4           +1.0
RFORCE  11                      .667                    1.0
SPC1    2       123456  1       THRU    14
```

POSTPROCESSOR DECK

```
 CARD GROUP DESIGNATION
 ┌───────────────────
 |        1         2         3         4         5         6         7         8
 | 1........0.........0.........0.........0.........0.........0.........0.........0
 |
1- TITLE= DEMONSTRATION PROBLEM NO. 6
1- TITLE= AIRCRAFT WING STRUCTURE BLADE
1- TITLE= WIND ENERGY STUDIES
2- POSTPROCESSING
2- SHELL/SPAR BLADE
3- ENDOPTIONS
4-    0   4   2
6-    1  10  50  55  70  75  99 110
```

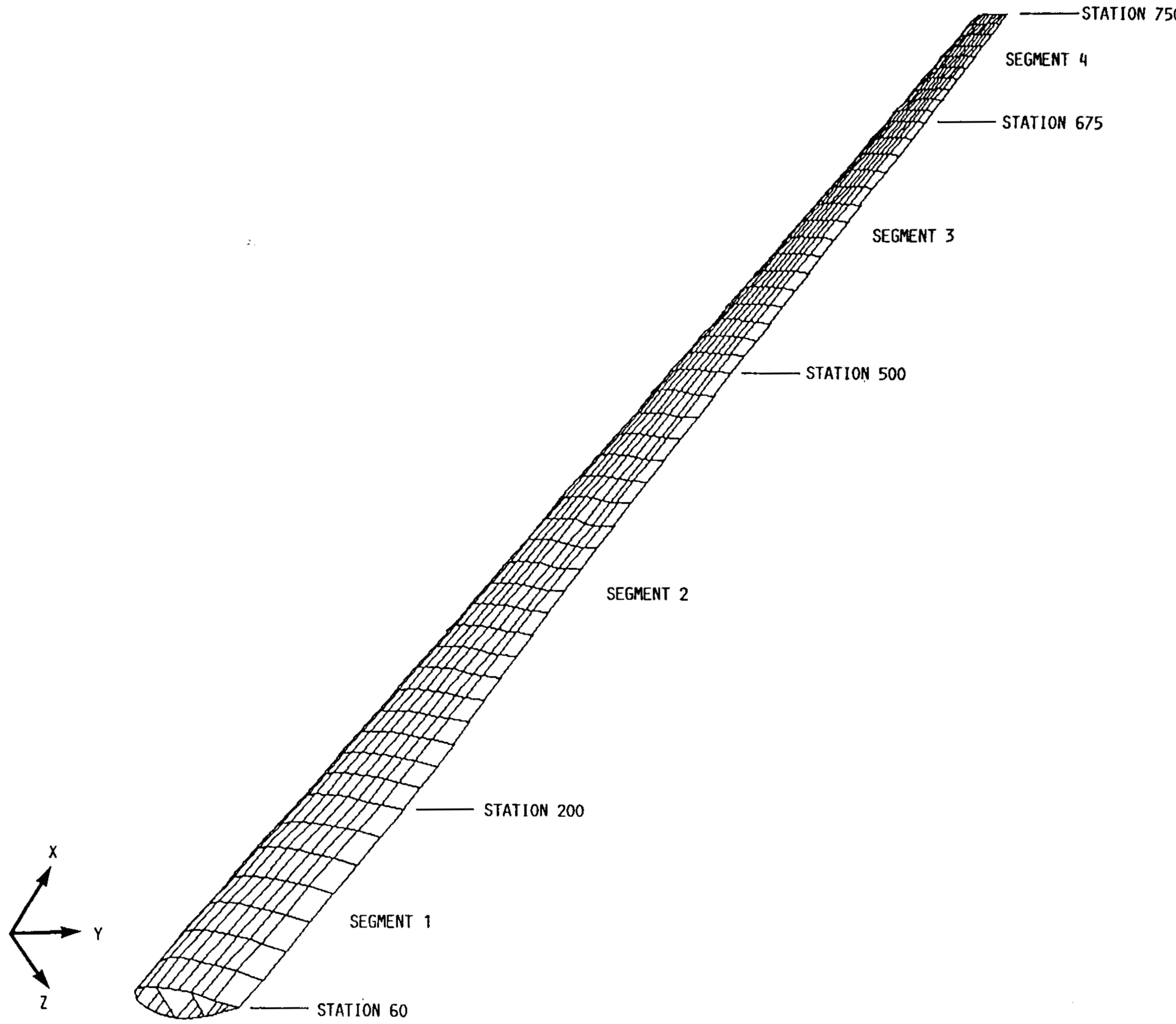
CARD GROUP 2
Two option cards are used in this postprocessing deck. POSTPROCESSING and SHELL/SPAR specify that postprocessing of stress output is requested for a structure modeled as an airfoil shell with internal spars.

CARD GROUP 3
Required ENDOPTIONS card.

CARD GROUP 4
Three integer values on this card are KSMF, NXSECT and NSPAR. KSMF is used to select the strain magnification factor to be used in establishing the limiting stress values for each ply layer in each node. Setting KSMF = 0 selects the default value which is recommended. The other integers are for the SHELL/SPAR option and are a repeat of values from the pre-processor deck.

CARD GROUP 6
Because the option PRTOUT was not selected in CARD GROUP 2 the user may select up to 10 grid point sequential sets for postprocessing output. For this problem four sequential sets were selected. Printed output will be provided for grid points 1 thru 10, 50 thru 55, 70 thru 75 and 99 thru 110. If no output is desired a blank record must be provided.

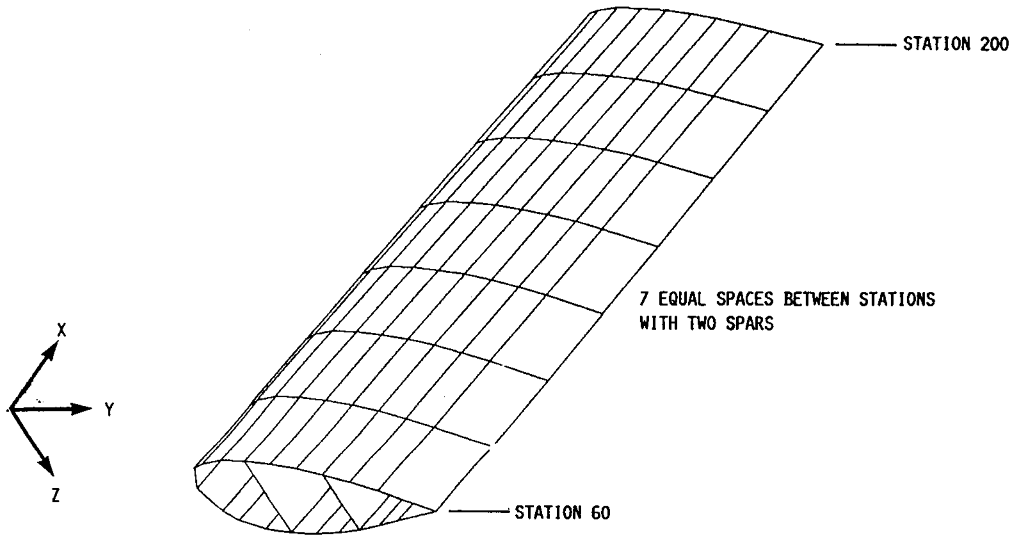
PLOT OF DEMO NO.6



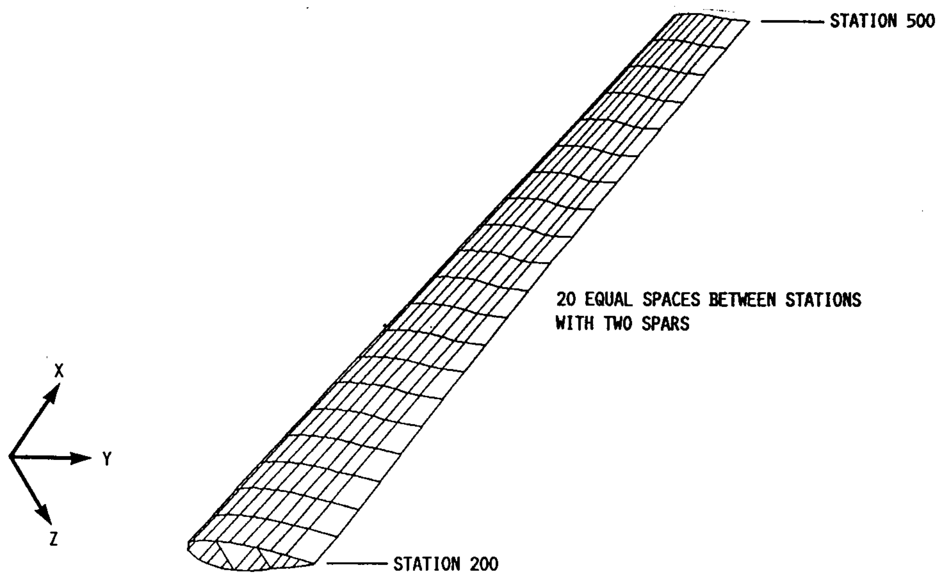
(A) FULL BLADE MODEL.

FIGURE 6. - DEMONSTRATION PROBLEM NUMBER 6, AIRCRAFT WING STRUCTURE BLADE.

PLOT OF DEMO NO.6



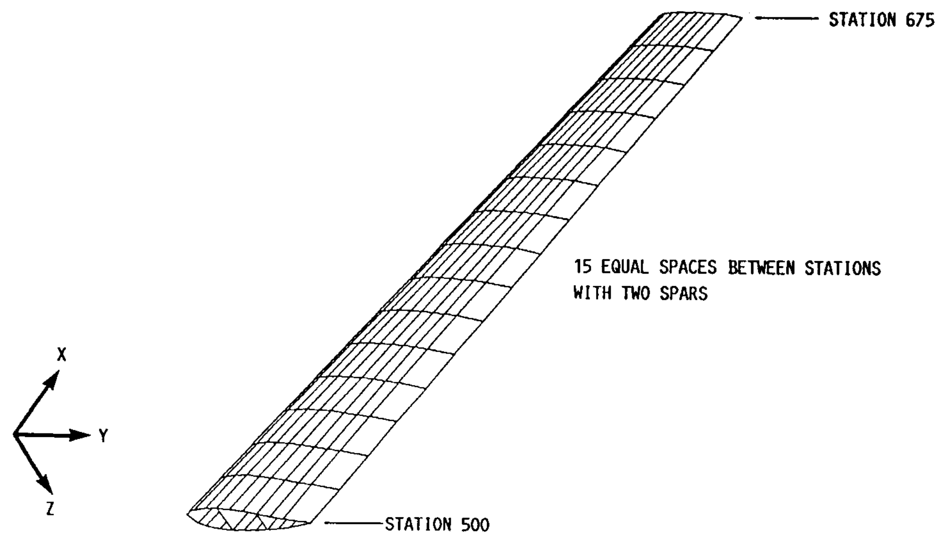
(B) SEGMENT 1.



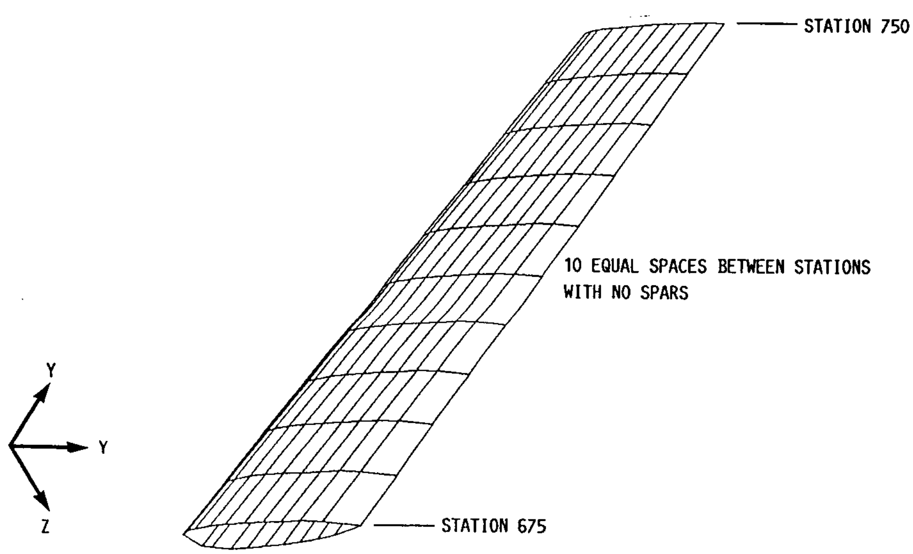
(C) SEGMENT 2.

FIGURE 6. - CONTINUED.

PLOT OF DEMO NO.6



(D) SEGMENT 3.



(E) SEGMENT 4.

FIGURE 6. - CONCLUDED.

PROBLEM NO. 7

This example demonstrates the basic characteristics of the datasets required to generate a COBSTRAN model of a wing structure with five spars oriented diagonally to the midchord line.

PREPROCESSOR DECK DESCRIPTION

CARD GROUP 2

These are the program options for this COBSTRAN problem. Each option is described in detail in the COBSTRAN USER'S MANUAL. Full printout is requested along with an echo of the input data. A NASTRAN bulk data deck containing PLOTEL cards will be generated for the model and the user will specify the ply layup order to be used to calculate material properties. The SHELL/SPAR option will call this alternate modeling feature to generate an airfoil shell model with internal spars. The ZIGZAG option indicates that the spar positions will be defined separately for the pressure and suction surfaces. Card Group 6 will require two cards for each line of data.

CARD GROUP 3

Required ENDOPTIONS card.

CARD GROUP 4

Anisotropic material properties generated for each node are to be based on reduced membrane properties and are requested by IMAT = 1. The number of material systems(plys) to be described in Card Group 8 of this input deck are designated by NDES = 4.

CARD GROUP 5

Three contiguous spanwise segments of the blade will be created for this model and is designated by NXSECT = 3.

The number of these segments that will contain spars is designated by NXSPAR = 3 and the number of spars by NSPAR = 5. All spars start at the base of the blade and extend through the number of segments specified by NXSPAR.

The number of chordwise spaces into which each cross section will be modeled is designated by NYSPC = 20. Each section is first divided equally into NYSPC spaces. Grid points are then adjusted to accommodate the spar positions. The points between spars, and between spars and leading or trailing edges are then equally spaced. Finally, the space at the leading edge is divided in two to provide a finer mesh on the normally highly curved leading edge. The resulting number of chordwise spaces is NYSPC+1 for the final model.

The value of NOPLY is left blank for this case therefore, extended ply property information will not be printed.

Only one ply material system may be designated for each spar. The array NSPDES(5) is used to indicate the ply designation number for each of the five spars. Five spars are modeled for this blade therefore, the next five integers indicate that ply designation numbers, 4 3 2 4 and 1 will be used to model each spar respectively. NSPDES(1)=4 , NSPDES(2)=3, NSPDES(3)=2, NSPDES(4)=4 and NSPDES(5)=1.

CARD GROUP 6

The number of spanwise spaces into which each blade segment will be divided is indicated by NXSPC and the range over which this applies is designated Xi and X(i+1). For this blade the first segment will be divided into 4 spaces between span stations 6.0 and 50.0. The second segment will be divided into 8 spaces between span stations 50.0 and 110.0. The third segment will be divided into 3 spaces between span stations 110.0 and 148.0. For each cross section defined, the spar locations measured from the leading edge, and the spar thickness are presented twice. The spar locations and thicknesses for the convex/suction surface are given on line 6a and the same values for the concave/pressure surface are given on line 6b. Grid points of each section of input in Card Groups 12 & 14. are positioned according to the spar positions defined in this Card Group. Values of the nearest lower Xi are used for each input section of Card Groups 12 & 14. All intermediate positions and thicknesses will be interpolated. The requirement for two separate spar locations for each segment is activated by the option ZIGZAG, otherwise spars will be generated normal to the blade chord line.

CARD GROUP 8

Four composite layers are specified. Each ply is represented by two physical records.

The first record defines the location of the ply on the blade by percent of thickness, span and chord. The first two values on this record refer to the initial and final percent thickness of the thickest grid point of the blade. The thickness calculated from the difference in these values divided by the ply thickness will determine the maximum number of layers of this particular ply at all other grid points, not to exceed the actual thickness at each grid point. The next two values are the initial and final percent span and the last two are initial and final percent chord as shown in Figure 10 of the USER'S MANUAL.

Note: Initial and final percent thicknesses are ignored when the PLYORDER option is specified.

The second record specifies fiber type, matrix type, ply thickness, void volume ratio, fiber volume ratio and orientation angle in degrees relative to the structural x-axis as shown in Figure 6 of the USER'S MANUAL.

CARD GROUP 9

The ply stack-up order for half-thickness is designated by 5 plys starting at the outer surface. Only the number of plys needed to fill the thickness will be used. If an insufficient number of plys is available an ERROR message will be printed. The ply designation numbers correspond to the order in which the plys are listed in CARD GROUP 8.

CARD GROUP 10

The profile input data is represented by two separate datasets. The first is for the concave/pressure surface of the blade where four sections are defined. The second is for the convex/suction surface of the blade where four sections are defined.

CARD GROUP 11

The number of grid points defining each of the four sections of input data in CARD GROUP 12 for the concave/pressure surface.

CARD GROUP 12

Each grid point defining the concave/pressure surface is designated as X, Y, Z, Thickness, Pressure, Temperature.

CARD GROUP 13

The number of grid points defining each of the four sections of input data in CARD GROUP 14 for the convex/suction surface.

CARD GROUP 14

Each grid point defining the convex/suction surface is designated as X, Y, Z, Thickness, Pressure, Temperature.

PREPROCESSOR DECK

```
 CARD GROUP DESIGNATION
 |
 |          1         2         3         4         5         6         7         8
 |  1........0.........0.........0.........0.........0.........0.........0.........0
 |
 1- TITLE= DEMONSTRATION PROBLEM NO. 7
 1- TITLE=  SHELL/SPAR TYPE BLADE
 1- TITLE=  STATIC LOAD CASE
 2-    PREPROCESSOR
 2-    SHELL/SPAR
 2-    ZIGZAG SPARS
 2-    DIAG = 54
 2-    MPLOTS
 2-    PLYORDER SPECIFIED
 3- ENDOPTIONS
 4-    1   4
 5-    3   3   5  20       4   3   2   4   1
6a-    4   6.0  12.0  .050  18.0  .050  18.0  .050  24.0  .050  24.0  .050
6b-             15.0  .050  15.0  .050  22.0  .050  22.0  .050  26.0  .050
6a-    8  50.0   9.5  .050  15.0  .050  15.0  .050  22.0  .040  22.0  .040
6b-             12.0  .040  12.0  .040  20.0  .040  20.0  .040  25.0  .040
6a-    3 110.0   7.0  .040  10.0  .040  10.0  .050  18.0  .040  18.0  .040
6b-              8.5  .040   8.5  .040  15.0  .040  15.0  .040  18.0  .040
6a-      148.0
6b-      148.0
 8-                      0.0       100.0     0.0       100.0
 8- T300 EPOX  .005      0.0       .60        90.0
 8-                      0.0       100.0     0.0       100.0
 8- T300 EPOX  .005      0.0       .60       -45.0
 8-                      0.0       100.0     0.0       100.0
 8- T300 EPOX  .005      0.0       .60       +45.0
 8-                      0.0       100.0     0.0       100.0
 8- T300 EPOX  .005      0.0       .60        0.0
 9-    5
 9-    1   2   4   3   4
10-    4   4
11-   11  11   9   7
12-      6.000   -18.000      .000       .050
         6.000   -14.400    -2.700       .050
         6.000   -10.800    -3.600       .050
         6.000    -7.200    -4.124       .050
         6.000    -3.600    -4.409       .050
         6.000     -.000    -4.500       .050
         6.000     3.600    -4.409       .050
         6.000     7.200    -4.124       .050
```

	6.000	10.800	-3.600	.050	
	6.000	14.400	-2.700	.050	
	6.000	18.000	0.0	.050	
	54.000	-14.943	1.307	.050	
	54.000	-12.150	-1.196	.050	
	54.000	-9.227	-2.204	.050	
	54.000	-6.277	-2.901	.050	
	54.000	-3.309	-3.399	.050	
	54.000	-.327	-3.736	.050	
	54.000	2.668	-3.922	.050	
	54.000	5.678	-3.947	.050	
	54.000	8.704	-3.773	.050	
	54.000	11.758	-3.287	.050	
	54.000	14.943	-1.307	.050	
	120.000	-9.659	2.588	.040	
	120.000	-7.672	.344	.040	
	120.000	-5.390	-.797	.040	
	120.000	-3.041	-1.691	.040	
	120.000	-.647	-2.415	.040	
	120.000	1.788	-2.985	.040	
	120.000	4.269	-3.385	.040	
	120.000	6.816	-3.538	.040	
	120.000	9.659	-2.588	.040	
	150.000	-4.330	2.500	.020	
	150.000	-3.353	.860	.020	
	150.000	-2.033	-.187	.020	
	150.000	-.625	-1.083	.020	
	150.000	.854	-1.854	.020	
	150.000	2.421	-2.474	.020	
	150.000	4.330	-2.500	.020	
13-	11 11 9 7				
14-	6.000	-18.000	.000	.050	
	6.000	-14.400	2.700	.050	2.5
	6.000	-10.800	3.600	.050	5.0
	6.000	-7.200	4.124	.050	10.0
	6.000	-3.600	4.409	.050	15.0
	6.000	-.000	4.500	.050	20.0
	6.000	3.600	4.409	.050	15.0
	6.000	7.200	4.124	.050	10.0
	6.000	10.800	3.600	.050	5.0
	6.000	14.400	2.700	.050	2.5
	6.000	18.000	0.0	.050	
	54.000	-14.943	1.307	.050	
	54.000	-11.758	3.287	.050	1.25
	54.000	-8.704	3.773	.050	2.5
	54.000	-5.678	3.947	.050	5.0
	54.000	-2.668	3.922	.050	10.0
	54.000	.327	3.736	.050	15.0

```
 54.000    3.309    3.399    .050  10.0
 54.000    6.277    2.901    .050  5.0
 54.000    9.227    2.204    .050  2.5
 54.000   12.150    1.196    .050  1.25
 54.000   14.943   -1.307    .050
120.000   -9.659    2.588    .040
120.000   -6.816    3.538    .040  1.25
120.000   -4.269    3.385    .040  2.5
120.000   -1.788    2.985    .040  5.0
120.000     .647    2.415    .040  10.0
120.000    3.041    1.691    .040  5.0
120.000    5.390     .797    .040  2.5
120.000    7.672    -.344    .040  1.25
120.000    9.659   -2.588    .040
150.000   -4.330    2.500    .020
150.000   -2.421    2.474    .020
150.000    -.854    1.854    .020
150.000     .625    1.083    .020
150.000    2.033     .187    .020
150.000    3.353    -.860    .020
150.000    4.330   -2.500    .020
```

DATABANK

Use the following data as the external databank to default to the internal databank.

```
        1         2         3         4         5         6         7         8
1.......0.........0.........0.........0.........0.........0.........0.........0

0
0
0
```

PLOT OF DEMO NO. 7

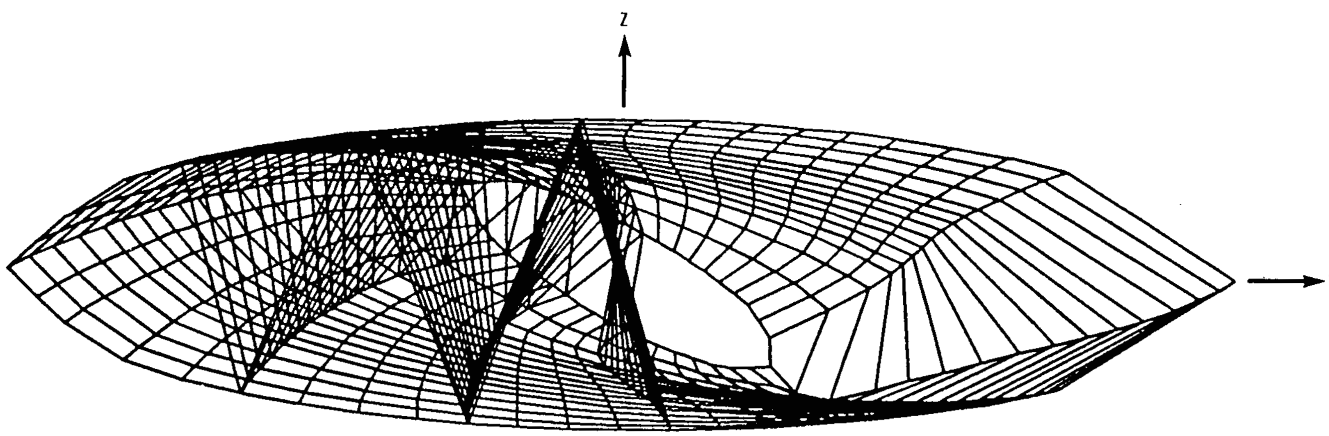


FIGURE 7. - DEMONSTRATION PROBLEM NUMBER 7, COBSTRAN ARBITRARY SPAR GENERATION.

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16. Abstract

This manual describes the input deck setup for a computer code, COBSTRAN (COmposite Blade STRuctural ANalyzer), developed for the design and analysis of composite turbofan and turboprop blades and also for composite wind turbine blades. This manual is intended for use in conjunction with the COBSTRAN USER'S MANUAL. Seven demonstration problems are described with pre- and postprocessing input decks. Modeling of blades which are solid thru-the-thickness and also aircraft wing airfoils with internal spars is shown. Corresponding NASTRAN and databank input decks are also shown. Detail descriptions of each line of the pre- and post-processing decks is provided with reference to the Card Groups defined in the USER'S MANUAL. A dictionary of all program variables and terms used in this manual may be found in Section 6 of the USER'S MANUAL.

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