EMWET User Manual
Student Version 1.5

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1 Introduction

The document is the user manual of "EMWET student version", a quasi-analytical weight prediction tool for aircraft wing. The way to prepare the input file for the tool, the command to execute it and the structure of the output file are illustrated in details and examples are given. For information related to the method implemented in the tool, its capability and limitation refer to lectures for MDO tutorial 4.

2 Input files

The tool needs two input files. One to define the wing geometry, the layout of the internal structure and material properties. The other one includes the sizing loads. These are specified in the following section.

2.1 Input file for geometry, structural and material properties

The first input file includes the geometry, structural and material properties. This file must named as xxx.init (xxx can be any letter and number but with no space between them). The structure of this file is the following. An example is provided in appendix A.

- new line (2 parameters): Maximum take-off weight and maximum zero fuel weight of aircraft in kg.
- new line (1 parameter): Maximum load factor.
- new line (4 parameter): wing reference area (m^2), wing span (m), number of sections used to define the wing planform and number of wing sections at which airfoils are provided.

- new line (2 parameters): in this line the dimensionless spanwise position ($y/(b/2)$) of the airfoil section and the name of input file including the coordinate of airfoil in that section should be written for each airfoil section (see figure 1). A separate line should be added for all the sections at which an airfoil coordinate is provided.
- new line (6 parameters): wing chord (m), x ,y and z coordinate of leading edge (m), chordwise location of front and rear spars (% local chord). A seprate line should be added for the sections used to define the wing planform geometry. (see figure 1 for geometry definition and figure 2 for the refrence axis).
- new line (2 parameters): dimensionless spanwise position ($y/(b/2)$) of start and end of the fuel tank in wing.
- new line (1 parameter): number of engines installed in EACH half wing (right wing).
- new line (2 parameters): spanwise position and weight (kg) of each engine. A new line should be added for the engines installed in EACH wing.
- new line (4 parameters): Young modulus (N/m^2), density (kg/m^3), tensile yield stress (N/m^2) and compressive yield stress (N/m^2) of the material used in upper panel.
- new line (4 parameters): Young modulus (N/m^2), density (kg/m^3), tensile yield stress (N/m^2) and compressive yield stress (N/m^2) of the material used in lower panel.
- new line (4 parameters): Young modulus (N/m^2), density (kg/m^3), tensile yield stress (N/m^2) and compressive yield stress (N/m^2) of the material used front spar.
- new line (4 parameters): Young modulus (N/m^2), density (kg/m^3), tensile yield stress (N/m^2) and compressive yield stress (N/m^2) of the material used rear spar.
- new line (2 parameters): stiffened panel efficiency factor for the upper panel (see figure 2) and rib pitch (m).
- new line (1 parameters): Display option. if this parameter is equal to 1, then the results of weight estimation will be written on the display. If this parameter is 0 nothing will be shown (still the results will be written in the output file).

The stiffened panel efficiency factor (F) depends on the type of stringer used. Figure 3 can be used to find values for various type of stiffeners.

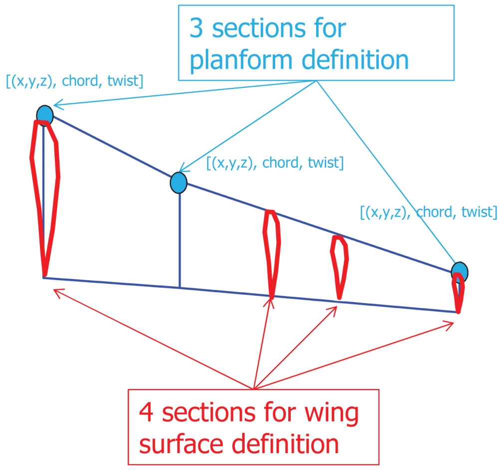


Figure 1: Example of sections at which the wing planform geometry and airfoils are defined.

2.1.1 Airfoil coordinate file

Each airfoil is defined as set of point coordinates (x ,y normalized with the chord length). The coordinate must be provided from the trailing edge (1,0) toward the leading edge on the upper surface (end point (0,0)) and back to the trailing edge on the lower surface (1,0). No additional comments should be in that file. The name of this file should be the same specified in xxx.init. These airfoil files must have ".dat" extension.

Examples of airfoil input files are provided both in the example directory of EMWET and in Apeendix C.

2.2 Load file

The load file must be named as xxx.load. The structure of this file should be as follow. An example is provided in Appendix B. The file consists of m [1] rows and 3 columns. The number of rows is equal to the number of wing spanwise positions at which load components are defined.

- first column: dimensionless spanwise position (from 0 to 1) of the section where the load is defined.
- second column: lift force applied at the given wing spanwise positions (N).
- third column: section pitching moment (computed w.r.t the quarter chord line) at the given spanwise positions (N.m).

[1] Make sure to define loads at least at 8 half wing sections.

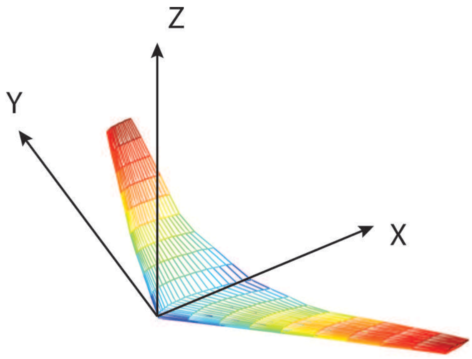
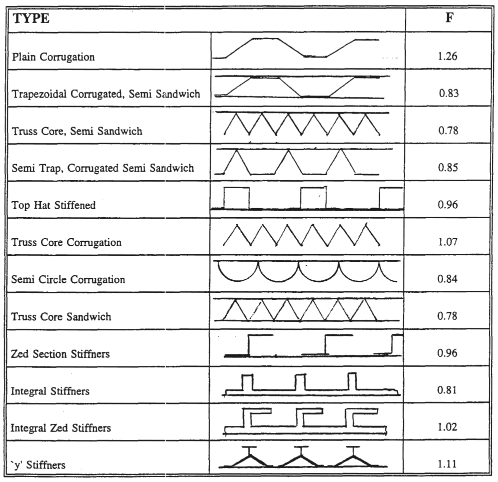


Figure 2: Reference system for defining the wing planform coordinates.



TYPE		F
Plain Corrugation		1.26
Trapezoidal Corrugated, Semi Sandwich		0.83
Truss Core, Semi Sandwich		0.78
Semi Trap, Corrugated Semi Sandwich		0.85
Top Hat Stiffened		0.96
Truss Core Corrugation		1.07
Semi Circle Corrugation		0.84
Truss Core Sandwich		0.78
Zed Section Stiffners		0.96
Integral Stiffners		0.81
Integral Zed Stiffners		1.02
'y' Stiffners		1.11

Figure 3: Stiffened panel efficiency factor.

3 Executing the tool

The tool can be executed using the following command:

EMWET xxx

where the xxx is the name of the input files. Make sure that all the input files are located in the same folder where the EMWET installed.

4 Output file

The tool creates the output file xxx.weight. This file includes the wing total weight (kg) and the thicknesses of the upper and lower panels and the front and rear spars in several spanwise section (tool decides about the position of those sections). The wing weight includes both the primary and the secondary (weight of flaps, slats, fixed leading edge and trailing edge, ailerons and spoilers) structural weights.

Appendix A

Example of the structure of the input file xxx.init

Attention: Do not write any comments in the input files. The comments added here are just for clarification.

```
52390 46720             | MTOW ZFW
2.5     | maximum load factor
91.04 28.35 3 4 | wing area, wing span, number of sections for defining planform
                          , number of sections for airfoils
0 b737a                 | location and name of airfoils
0.33 b737b              | location and name of airfoils
0.7 b737c               | location and name of airfoils
1 b737d                 | location and name of airfoils
7.38 12.9 0 5 0.1 0.61              | chord, x, y, z, front spar and rear spar position
4.02 16.25 4.7 5.84 0.16 0.63       | chord, x, y, z, front spar and rear spar position
1.51 21.29 14.175 6.67 0.22 0.55    | chord, x, y, z, front spar and rear spar position
0.1 0.9                 | start and end location of the fuel tank
1                       | number of engine in each wing
0.35 1969               | spanwise location and weight of installed engine
7.10185e+010 2795.68 4.8265e+008 4.6886e+008           | Young's modulus, density,
 tensile and compressive yield stresses
7.37765e+010 2795.68 3.24065e+008 2.68905e+008
7.10185e+010 2795.68 4.8265e+008 4.6886e+008
7.10185e+010 2795.68 4.8265e+008 4.6886e+008
0.96 0.5                | stiffened panel efficiency factor  rib pitch
1 | display option
```

Appendix B

Example of the structure of the input file xxx.load

Attention: Do not write any comments in the input files. The comments added here are just for clarification.

```
    spanwise position    Lift    Pitching moment
0          5.9916e4   -4.3351e4
    0.0714     5.8869e4   -3.3323e4
    0.1429     5.6665e4   -2.5408e4
    0.2143    5.3796e4   -1.9036e4
    0.2857      5.0745e4   -1.3604e4
    0.3571     4.7936e4   -0.8953e4
    0.4286     4.5594e4   -0.6156e4
    0.5000     4.3550e4   -0.5127e4
    0.5714     4.1264e4   -0.4322e4
    0.6429     3.8616e4   -0.3374e4
    0.7143     3.5631e4   -0.2433e4
    0.7857     3.2075e4   -0.1220e4
    0.8571     2.7642e4    0.0852e4
    0.9286     2.0645e4    0.4002e4
    1.0000     0.2659e4    0.2260e4
```

Appendix C Example of the structure of the airfoil coordinate file

Attention: Do not write any comments in the input files. The comments added here are just for clarification.

```
1.0000000e+000  0.0000000e+000         | trailing edge
9.5032000e-001  9.7600000e-003
9.0066000e-001  1.9820000e-002
8.5092000e-001  3.0200000e-002
8.0109000e-001  4.0620000e-002
7.5115000e-001  5.0840000e-002
6.5096000e-001  6.9540000e-002
6.0072000e-001  7.7620000e-002
5.5040000e-001  8.4560000e-002
4.4954000e-001  9.4140000e-002
3.4853000e-001  9.5410000e-002         | upper surface
2.4756000e-001  8.7710000e-002
1.4681000e-001  7.1220000e-002
9.6620000e-002  5.8640000e-002
7.1620000e-002  5.0750000e-002
9.9600000e-003  2.0380000e-002
5.2600000e-003  1.5790000e-002
2.9900000e-003  1.2910000e-002
0.0000000e+000  0.0000000e+000         | leading edge
9.7400000e-003 -1.2990000e-002
1.5040000e-002 -1.6100000e-002
2.7930000e-002 -2.1390000e-002
7.8380000e-002 -3.3790000e-002
1.0338000e-001 -3.7960000e-002
1.5319000e-001 -4.4300000e-002
2.0286000e-001 -4.8820000e-002         | lower surface
2.5244000e-001 -5.1910000e-002
3.0197000e-001 -5.3720000e-002
4.0096000e-001 -5.3300000e-002
4.5046000e-001 -5.0340000e-002
5.0000000e-001 -4.6040000e-002
5.4960000e-001 -4.0760000e-002
6.4904000e-001 -2.8340000e-002
6.9889000e-001 -2.1670000e-002
8.4908000e-001 -3.2800000e-003
9.4968000e-001  2.8800000e-003
1.0000000e+000  0.0000000e+000        | trailing edge
```

Appendix D

Example of the output file xxx.weight

Wing total weight(kg) 4436.79

y/(b/2)	Chord[m]	tu[mm]	tl[mm]	tfs[mm]	trs[mm]
0.02	6.89	3.9	5.7	2.1	1.6
0.06	6.54	4.1	6	2.2	1.6
0.09	6.19	4.4	6.3	2.2	1.7
0.13	5.84	4.7	6.8	2.3	1.8
0.17	5.49	5	7.2	2.4	2
0.2	5.14	5.4	7.8	2.4	2.1
0.24	4.79	5.9	8.5	2.5	2.3
0.28	4.44	6.4	9.3	2.7	2.5
0.31	4.09	7.2	10.4	2.8	2.8
0.35	3.75	8	11.6	2.9	3
0.39	3.62	7.5	10.9	2.9	3
0.43	3.49	7.1	10.3	2.8	2.8
0.46	3.36	6.8	9.8	2.6	2.7
0.5	3.23	6.3	9.1	2.5	2.5
0.54	3.1	5.7	8.3	2.3	2.4
0.57	2.97	5.1	7.4	2.1	2.2
0.61	2.84	4.8	6.9	2	2
0.65	2.71	4.2	6	1.8	1.8
0.69	2.58	3.5	5.1	1.6	1.7
0.72	2.45	3.1	4.5	1.5	1.5
0.76	2.32	2.7	3.6	1.3	1.3
0.8	2.19	2.4	2.7	1.1	1.1
0.83	2.06	2.1	2.1	0.9	0.8
0.87	1.93	1.7	1.3	0.8	0.8
0.91	1.8	1.3	0.8	0.8	0.8
0.94	1.67	0.8	0.8	0.8	0.8
0.98	1.54	0.8	0.8	0.8	0.8