

3
THIS REPORT HAS BEEN DELIMITED
AND CLEARED FOR PUBLIC RELEASE
UNDER DOE DIRECTIVE 5200.20 AND
NO RESTRICTIONS ARE IMPOSED UPON
ITS USE AND DISCLOSURE

DECLASSIFICATION STATEMENT A

APPROVED FOR PUBLIC RELEASE
DISTRIBUTION UNLIMITED

UNCLASSIFIED

AD 142154

Armed Services Technical Information Agency

**ARLINGTON HALL STATION
ARLINGTON 12 VIRGINIA**

☐ FOR
☐ MICRO-CARD
☐ CONTROL ONLY

1 OF 2

NOTICE: WHEN GOVERNMENT OR OTHER DRAWINGS, SPECIFICATIONS OR OTHER DATA ARE USED FOR ANY PURPOSE OTHER THAN IN CONNECTION WITH A DEFENSE-RELATED GOVERNMENT PROCUREMENT OPERATION, THE U. S. GOVERNMENT THEREBY INCURS NO RESPONSIBILITY, NOR ANY OBLIGATION WHATSOEVER, AND THE FACT THAT THE GOVERNMENT MAY HAVE FORMULATED, FURNISHED, OR IN ANY WAY SUPPLIED THE SAID DRAWINGS, SPECIFICATIONS, OR OTHER DATA IS NOT TO BE REGARDED BY IMPLICATION OR OTHERWISE AS IN ANY MANNER LICENSING THE HOLDER OR ANY OTHER PERSON OR CORPORATION, OR CONVEYING ANY RIGHTS OR PERMISSION TO MANUFACTURE, USE OR SELL ANY PATENTED INVENTION THAT MAY IN ANY WAY BE RELATED THERETO.

UNCLASSIFIED

WADC TECHNICAL NOTE 57-310 ✓
ASTIA DOCUMENT No. AD 142154

FC

35

**TABULAR PRESENTATION OF
SUPERSONIC FLUTTER TRENDS FROM
PISTON THEORY CALCULATIONS**

**WARREN H. WEATHERILL
GARABED ZARTARIAN**

MASSACHUSETTS INSTITUTE OF TECHNOLOGY

JANUARY 1958

**This report is not to be announced or distributed
automatically in accordance with AFR 205-43A,
paragraph 6d.**

WRIGHT AIR DEVELOPMENT CENTER

AD NO. 142154

ASTIA FILE COPY

AD NO. 142154

ASTIA FILE COPY

(2)

WADC TECHNICAL NOTE 57-310
ASTIA DOCUMENT No. AD 142154

**TABULAR PRESENTATION OF
SUPERSONIC FLUTTER TRENDS FROM
PISTON THEORY CALCULATIONS**

*WARREN H. WEATHERILL
GARABED ZARTARIAN*

MASSACHUSETTS INSTITUTE OF TECHNOLOGY

JANUARY 1958

AIRCRAFT LABORATORY
CONTRACT No. AF33(616)-2482
PROJECT No. 1370

WRIGHT AIR DEVELOPMENT CENTER
AIR RESEARCH AND DEVELOPMENT COMMAND
UNITED STATES AIR FORCE
WRIGHT-PATTERSON AIR FORCE BASE, OHIO

FOREWORD

This note, which presents results from parameteric flutter studies on a typical section airfoil using piston theory, was prepared by the Aeroelastic and Structures Research Laboratory, Massachusetts Institute of Technology, Cambridge 39, Massachusetts, for the Aircraft Laboratory, Wright Air Development Center, Wright-Patterson Air Force Base, Ohio. The work was performed at the MIT under the direction of Professor Holt Ashley and supervised by Mr. G. Zartarian and Mr. W. H. Weatherill. The research and development work was accomplished under Air Force Contract No. AF33(616)-2482, Project No. 1370, "Aeroelasticity, Vibration and Noise", and Task No. 13478, "Theoretical Supersonic Flutter Studies". Mr. Walter J. Mykytow of the Dynamics Branch, Aircraft Laboratory is task engineer. This note contains data only and represents a part of a research program on the flutter of aircraft structures at supersonic speeds. Further reports will be published as the research continues. The basic research was started 1 July 1954 and is continuing. As part of this research WADC Technical Report ^{AD-110591} 56-97, (Confidential Report - Unclassified Title) "Theoretical Studies on the Prediction of Unsteady Supersonic Airloads on Elastic Wings" has been published in two separate parts. Part I, (Unclassified Title) "Investigations on the Use of Oscillatory Supersonic Aerodynamic Influence Coefficients" which presents the studies on the use of the aerodynamic influence coefficient method, was issued in December 1955; and Part II, ^{AD-110592} (Unclassified Title) "Rules for Application of Oscillatory Supersonic Aerodynamic Influence Coefficients" which presents working rules and recommendations for flutter analysis using the aerodynamic-influence-coefficient method, was issued in February 1956.

FOREWORD (Continued)

The authors are indebted to Professor Holt Ashley and Dr. P. T. Hsu for their contributions to the research. Also, acknowledgements are due to Mrs. Ruth Lyon and her computing group for their help in making the necessary calculations, Mr. John McHugh for help in preparing the tables and figures and Miss Kathryn Roberts for typing the final manuscript.

ABSTRACT

An extensive set of tables is presented from binary flutter calculations on the typical section airplane wing model of Theodorsen and Garrick (Ref. 1). The airloads are predicted using two-dimensional piston theory. The parameters studied include thickness as well as center of gravity position, elastic axis position, wing and aileron radii of gyration, and frequency ratio. The three binary flutter cases for which data is given are bending-torsion, bending-aileron, and torsion-aileron flutter.

PUBLICATION REVIEW

This report has been reviewed and is approved.

FOR THE COMMANDER:

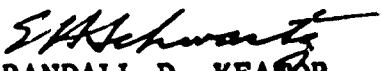
for 
RANDALL D. KEATOR
Colonel, USAF
Chief, Aircraft Laboratory
Directorate of Laboratories

TABLE OF CONTENTS

<u>Section</u>	<u>Page</u>
I Parametric Study of Flutter at High Supersonic Speeds	1
1. Introduction	1
2. Development of Flutter Equations	3
3. Description of Results	6
Bibliography	74
Appendix	75

LIST OF ILLUSTRATIONS

<u>Figure</u>		<u>Page</u>
1	The Model Used For Flutter Analysis	4
2	Graph of Flight Capability of Typical Aircraft in Terms of Altitude and Mach Number	75
3	Flight Capability of Typical Aircraft in Terms of μM and $\mu b \omega_a / a$	75
4	Flutter Boundary Superimposed on Flight Boundary for Typical Aircraft in Terms of μM and $\mu b \omega_a / a$	76

LIST OF TABLES

<u>Table</u>		<u>Page</u>
1	Bending-Torsion Flutter	8
2	Bending-Aileron	13
3	Torsion-Aileron	14
4-50	$\mu b \omega_a / a$ For Bending-Torsion Flutter	15-61
51-56	$\mu b \omega_h / a$ For Bending-Aileron Flutter	62-67
57-62	$\mu b \omega_a / a$ For Torsion-Aileron Flutter	68-73

LIST OF SYMBOLS

a	speed of sound
b	semi-chord of wing
h	vertical displacement of elastic axis as function of t . (See Fig. 1)
$()_F$	conditions at flutter
I_α	mass moment of inertia of wing-aileron combination about elastic axis per unit span
I_β	mass moment of inertia of aileron about hingeline per unit span
k	reduced frequency of simple harmonic motion
$L_1, \dots, L_6$	dimensionless coefficients defining lift on an oscillating wing
m	mass per unit length
M	free stream Mach Number
$M_1, \dots, M_6$	dimensionless coefficients defining moment on an oscillating wing
r_α	radius of gyration of wing-aileron combination referred to elastic axis $(r_\alpha = \sqrt{\frac{I_\alpha}{mb^2}})$
r_β	radius of gyration of aileron
S_α	static unbalance of wing-aileron combination per unit span referred to the elastic axis
S_β	static moment of aileron per unit span referred to aileron hinge
t	physical time
U	free stream velocity or flight speed
w	vertical component of velocity (velocity in z -direction)

LIST OF SYMBOLS (Continued)

x_0	position of elastic axis referred to leading edge (non-dimensionalized with respect to $2b$)
x_1	position of hingeline referred to leading edge (non-dimensionalized with respect to $2b$)
x_α	non-dimensional location of cg of wing-aileron combination referred to the elastic axis ($x_\alpha = \frac{x_\alpha}{mb}$)
x_β	non-dimensional location of center of gravity of aileron referred to hingeline ($x_\beta = \frac{x_\beta}{mb}$)
α	angular displacement of wing about elastic axis as function of t . (See Fig. 1).
β	angular displacement of aileron measured with respect to α as function of time (See Fig. 1).
$\delta(x)$	thickness distribution non-dimensionalized with respect to $2b$.
$\bar{\delta}$	a thickness quantity defined as $0.6 \frac{\delta}{b}$
μ	mass density ratio defined as $\frac{m}{4\rho b^2}$
ρ	density
ω	natural frequency at flutter
ω_1	first natural bending frequency of wing
ω_α	natural torsional frequency of wing about the elastic axis
ω_β	natural torsional frequency of aileron about hingeline
χ	defined as $\left(\frac{\omega_1}{\omega}\right)^2$

SECTION 1

PARAMETRIC STUDY OF FLUTTER AT HIGH SUPERSONIC SPEEDS

1. Introduction

The objective of this report is to present the numerical results of extensive binary flutter calculations on the typical section airplane wing model of Theodorsen and Garrick (Ref. 1) with two-dimensional piston theory used for the aerodynamic terms in the flutter equations. The effects of all dimensionless system parameters on the flutter eigenvalues are included.

In order to expedite publication, no graphical presentations or interpretation of results are given herein. This is therefore an interim report, designed to make the data generally available while a more complete paper is being prepared on the same subject. The final report will contain no additional numerical information but will be devoted to interpretation of findings and discussion of ways in which the material can be used.

Piston theory is an approximate technique for estimating airloads on airfoils in unsteady motion at higher supersonic and low hypersonic speeds. It had its origins in work of Hayes (Ref. 2) and Lighthill (Ref. 3) and has been applied to aero-elastic problems in several recent publications (e.g., Refs. 4 and 5). Its use for typical section flutter analyses is desirable for several reasons. First, it yields a much simplified set of equations of motion, as compared with more conventional unsteady aerodynamic theory. In some cases the flutter determinant may even be solved in closed form. Extensive flutter calculations using piston theory can be made on any small digital computing machine, such as the Durrroughs E101 which was employed in the present investigation. Second, the influence of airfoil thickness (and other nonlinear effects, if significant) can be introduced without excessive additional computational difficulty. To the authors' knowledge, this is the first parametric study of flutter which includes thickness effects. Although by no means exhaustive, the ranges of parameters covered appear to be those of general interest for the supersonic flight regime.

Manuscript released by the authors May 1957 for publication as a
WADC Technical Note.

In setting up the flutter problem for this report, a three-degree-of-freedom determinant was first derived for the system pictured in Fig. 1. Only the three sub-cases of binary flutter were calculated, however. Thus the tables list data only on bending-torsion, bending-aileron and torsion-aileron flutter of the typical section.

The flutter equations and their solution follow the pattern established by Garrick and Rubinow (Ref. 6). A symmetrical double-wedge airfoil shape has been chosen as typical of supersonic configurations.

Section 2 gives the computational details, while Section 3 discusses the manner of tabular presentation of data. In this latter connection, a few remarks are in order. Past convention has usually been to present compressible-flow-flutter boundaries on plots of dimensionless speed* (e.g. $U_r/b\omega_a$) vs. Mach number M . On such a plot, flight of a given aircraft at a given altitude is represented by a sloping straight line through the origin of coordinates. A flutter-free condition for the given altitude occurs at any M where the actual flutter curve lies above this "altitude line". This form of presentation has the disadvantage that the airspeed is contained implicitly in both the ordinate and abscissa of the stability diagram. It has been pointed out (Ref. 6) that the flutter stability boundary can equally well be presented as a curve of $b\omega_a/a$ vs. M , where a is the speed of sound at flight altitude. Flight of a given aircraft at a given altitude is then described by a horizontal straight line; no flutter occurs if this straight line lies above the actual flutter curve. Alternatively, the flutter curve can be interpreted in terms of the torsional stiffness required for safe flight of a wing of given geometry at a given speed of sound and Mach number.

It has been pointed out that the curves for various altitudes can be brought in closer juxtaposition by multiplying the ordinate $b\omega_a/a$ by some power of the wing-to-air density ratio μ (thus, $\mu^{1/2}$ can be interpreted in terms of indicated rather than true airspeed). For this reason, and because μ and M always appear as the product μM in the analysis, all flutter data in the present report are given as tables of $\mu^{1/2} b\omega_a/a$ (or $\mu^{1/2} b\omega_a/a$) vs. μM , each row representing the ordinates of the stability boundary for one set of dimensionless parameters.

*See List of Symbols for definitions of all physical quantities.

2. Development of Flutter Equations

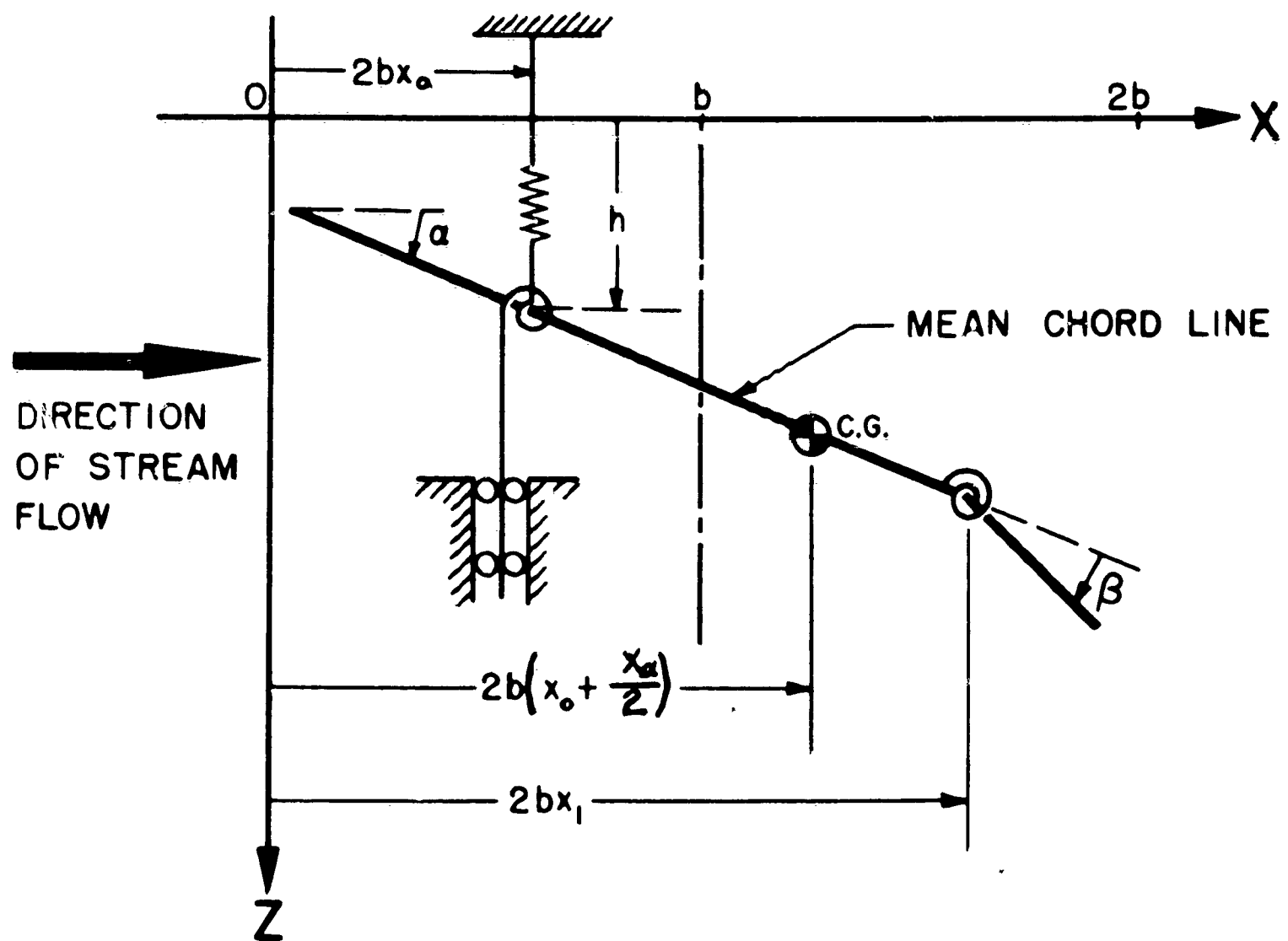
Figure 1a illustrates the two-dimensional dynamic model which forms the basis of this trend study on supersonic flutter. It is identical with the "typical section" model used by Theodorsen and Garrick (Refs. 1 and 6). This system has three degrees of freedom, described by the time-dependent quantities h , α , and β , which are analogous to bending, torsion and control-surface rotation, respectively, of an unswept wing or tail surface. When the equations of motion of this model in a supersonic airstream are set up, under the assumption that h , α , β , vary simple-harmonically with time, there results the well-known flutter determinant (cf. Ref. 6). This complex determinant, whose vanishing supplies two characteristic equations for the flutter eigenvalues U_f and ω_f , is of third order in the present example:

$$\begin{vmatrix} A & B & C \\ D & E & F \\ G & H & I \end{vmatrix} = 0 \quad (1)$$

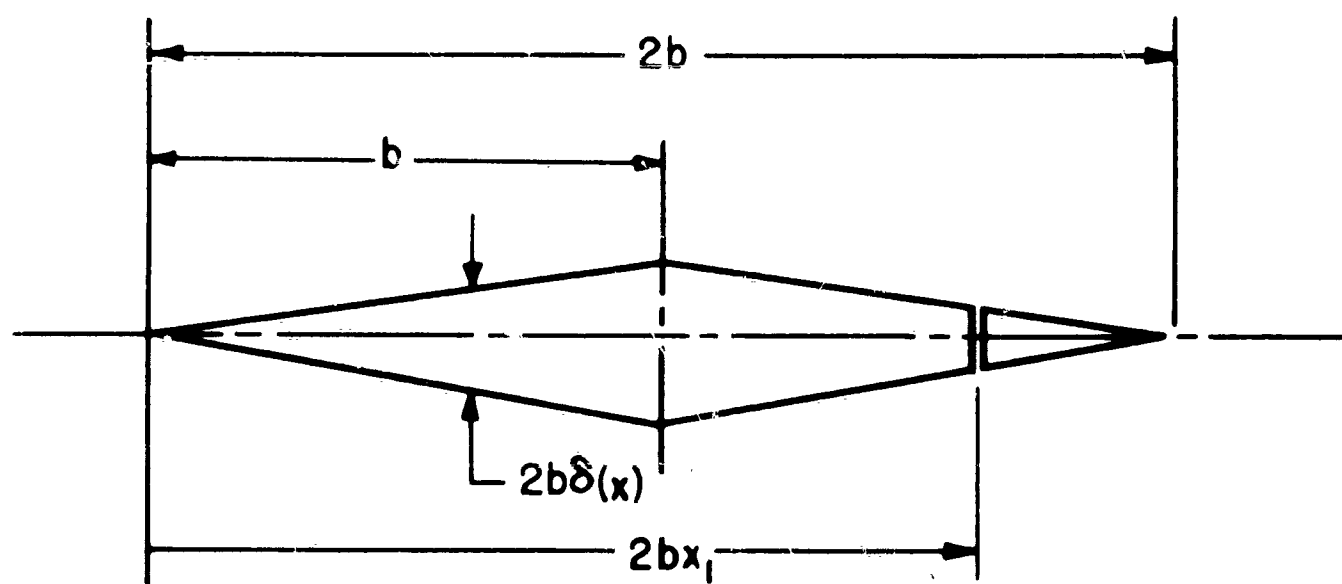
In terms of quantities defined in the List of Symbols, the elements of Eq. (1) are the following:

$$\begin{aligned} A &= \mu \left\{ \left(\frac{u_h}{u_\infty} \right)^2 \chi - 1 \right\} + L_1 + iL_2 \\ B &= -\mu \chi_\alpha + L_3 + iL_4 \\ C &= -\mu \chi_\beta + L_5 + iL_6 \\ D &= -\mu \chi_\alpha + M_1 + iM_2 \\ E &= \mu r_\alpha^2 \left\{ \chi - 1 \right\} + M_3 + iM_4 \\ F &= -\mu \left[r_\beta^2 + 2(\chi_1 - \chi_0) \chi_\beta \right] + M_5 + iM_6 \\ G &= -\mu \chi_\beta + N_1 + iN_2 \\ H &= -\mu \left[r_\beta^2 + 2(\chi_1 - \chi_0) \chi_\beta \right] + N_3 + iN_4 \\ I &= \mu r_\beta^2 \left\{ \left(\frac{u_\beta}{u_\infty} \right)^2 \chi - 1 \right\} + N_5 + iN_6 \end{aligned} \quad (2)$$

Here $(L_1 + iL_2)$, etc., are dimensionless representations of the lifts, pitching moments and control-surface hinge moments due to simple harmonic motions in the three degrees of freedom. The definitions adopted here coincide with those originally given by Garrick and Rubinow (Ref. 6). For sufficiently high supersonic



(a) DYNAMIC MODEL OF AIRFOIL SECTION



(b) GEOMETRICAL SHAPE OF AIRFOIL SECTION

Fig. 1 The Model Used For Flutter Analysis

flight Mach number M , these coefficients can be put into the relatively simple forms yielded by piston theory (Ashley and Zartarian, Ref. 5). Assuming a symmetrical double-wedge airfoil section of chord $2b$ and thickness ratio δ , and accounting for the second-order effect of thickness, Zartarian, Heller and Ashley (Ref. 4) give the following:

$$L_1 = 0$$

$$L_2 = \frac{1}{Mk}$$

$$L_3 = \frac{1}{Mk^2}$$

$$L_4 = \frac{1}{Mk} \{ (1-2x_0) - \mu M \delta \}$$

$$L_5 = \frac{(1-x_1)}{Mk^2} \{ 1 - 2\mu M \delta \}$$

$$L_6 = \frac{(1-x_1)^2}{Mk} \{ 1 - 2\mu M \delta \}$$

$$M_1 = 0$$

$$M_2 = \frac{1}{Mk} \{ (1-2x_0) - \mu M \delta \}$$

$$M_3 = \frac{1}{Mk^2} \{ (1-2x_0) - \mu M \delta \}$$

$$M_4 = \frac{1}{Mk} \left\{ \frac{1}{3} + (1-2x_0)^2 - 2(1-2x_0)\mu M \delta \right\}$$

$$M_5 = \frac{(1-x_1)[(1-2x_0)+x_1]}{Mk^2} \{ 1 - 2\mu M \delta \}$$

$$M_6 = \frac{(1-x_1)^2[(1-2x_0)+\frac{2}{3}x_1+\frac{1}{3}]}{Mk} \{ 1 - 2\mu M \delta \}$$

$$N_1 = 0$$

$$N_2 = \frac{(1-x_1)^2}{Mk} \{ 1 - 2\mu M \delta \}$$

$$N_3 = \frac{(1-x_1)^3}{Mk^2} \{ 1 - 2\mu M \delta \}$$

$$N_4 = \frac{(1-x_1)^2[(1-2x_0)+\frac{2}{3}x_1+\frac{1}{3}]}{Mk} \{ 1 - 2\mu M \delta \}$$

$$N_5 = \frac{(1-x_1)^3}{Mk^2} \{ 1 - 2\mu M \delta \}$$

$$N_6 = \frac{4(1-x_1)^3}{3Mk} \{ 1 - 2\mu M \delta \}$$

(3)

As in Ref. (1), the present report concentrates on the influence of various system parameters on solutions of the flutter determinant "Eq (1)" for the sub-cases obtained by successively suppressing each of the degrees of freedom. The determinants for these three binary flutters are

(1) Bending - torsion flutter:

$$\begin{vmatrix} A & B \\ D & E \end{vmatrix} = 0 \quad (4)$$

(2) Bending-aileron flutter:

$$\begin{vmatrix} A & C \\ G & I \end{vmatrix} = 0 \quad (5)$$

(3) Torsion-aileron flutter:

$$\begin{vmatrix} E & F \\ H & I \end{vmatrix} = 0 \quad (6)$$

It is significant that the bending-torsion sub-case can be solved explicitly for the dimensionless speed and frequency of flutter:

$$\frac{U_F}{b\omega_a} = \mu M \sqrt{\frac{x_a^2 - [(\frac{\omega_a}{\omega})^2 \chi - 1][\chi - 1]r_a^2}{(\mu M \{ (1-2x_a - \mu M \delta) [(\frac{\omega_a}{\omega})^2 \chi - 1] + x_a \} + (\mu M \delta)^2 - \frac{1}{3}) \chi}}$$

$$\chi = \frac{r_a^2 - 2x_a(1-2x_a - \mu M \delta) + [\frac{1}{3} + (1-2x_a)^2 - 2(1-2x_a)\mu M \delta]}{r_a^2 + (\frac{\omega_a}{\omega})^2 \{ \frac{1}{3} + (1-2x_a)^2 - 2(1-2x_a)\mu M \delta \}} = \left(\frac{\omega_a}{\omega} \right)^2$$

These expressions display explicitly the influence of the various system parameters and combinations thereof on the eigenvalues. It is unfortunate that similar closed-form solutions cannot be written down for the other two binary flutter cases. From the computational standpoint, however, the implicit equations yielded by the bending-aileron and torsion-aileron determinants can be solved for speed and frequency with nearly equal ease.

3. Description of Results

The combinations of parameters used for each binary flutter solution are listed in Tables 1-3.

Tables 4 through 62 contain all the calculated results. Blank spaces indicate that no calculations were made. Asterisks indicate that careful examination of the equations shows that no

solutions exist. Dashes in the boxes mean that calculations were made and no real solutions were found.

The numbers contained in the tables, as mentioned in the Introduction, are values of $\mu b \omega_a / a$ at flutter for the particular combination of parameters involved. The tables are setup with the purpose of making curves of $\mu b \omega_a / a$ versus μM for a series of values of thickness ratio with other parameters fixed. $\mu b \omega_a / a$ was chosen because, for a given configuration (values of b , ω_a and m fixed) and altitude, $\mu b \omega_a / a$ is represented by a straight horizontal line in a graph of $\mu b \omega_a / a$ versus μM . Also, a flight diagram showing the design capabilities of a particular aircraft may be superimposed on a plot of $\mu b \omega_a / a$ versus μM . The Mach number, M , always appears in linear combination with μ , thus μM was considered to be the most convenient and economical scale for the abscissa (cf. Eq. 7). Note that μ also appears with the thickness parameter in the single combination δ/μ . An example of drawing a flutter boundary on a flight diagram is given in the Appendix. Although the tables are set up to be used to show trends due to thickness, the reader should have no trouble in combining any set of numbers to illustrate desired trends.

All the results were obtained for a typical section of a symmetrical double wedge airfoil section of chord $2b$ and thickness $2\delta b$. For the modes used in this report (first power in x only), as shown in ref. 5, the actual profile of the wing enters the piston theory aerodynamic derivatives only in the form of the area of the airfoil section, the area of the flap, the first area moments of the wing and flap about their leading edges, and the thickness of the profile at the hinge line, all non-dimensionalized with respect to the semichord. If these parameters can be made numerically equal for two different profiles (say by adjusting the thickness parameter), then the two profiles would have the same aerodynamic derivatives. This may be done only for special systems for the binary cases including the aileron mode and for the ternary system where three or more of the above conditions must be satisfied. However, for the bending-torsion system, where only the area and first area-moment conditions must be satisfied, similarity rules may be found between all profiles having the same non-dimensional centroid of area location. For example, a doubly symmetric biconvex airfoil section with parabolic thickness distribution of maximum thickness $2b\delta_{ac}$ will have the same bending-torsion flutter boundary as the double-wedge section of this report of maximum thickness $2b$ ($4\delta_{ac}/3$). This of course assumes that all other system parameters are identical. These various aspects will be further discussed in the final report.

BENDING-TORSION FLUTTER						
x_a	x_o	r_a^2	δ/μ	ω_h/ω_a	Table No.	Page No.
0	0.35	0.09	0 0.000,5 0.001	0- 1.5 0- 1.5 0- 1.5	4	15
		0.16	0 0.000,5 0.001	0- 1.5 0- 1.5 0- 1.5	5	16
		0.25	0 0.000,5 0.001	0- 1.5 0- 1.5 0- 1.5	6	17
	0.4	0.09	0 0.000,5 0.001	0- 1.5 0- 1.5 0- 1.5	7	18
		0.16	0 0.000,5 0.001	0- 1.5 0- 1.5 0- 1.5	8	19
		0.25	0 0.000,5 0.001	0- 1.5 0- 1.5 0- 1.5	9	20
	0.45	0.09	0 0.000,5 0.001	0- 1.5 0- 1.5 0- 1.5	10	21
		0.16	0 0.000,5 0.001	0- 1.5 0- 1.5 0- 1.5	11	22
		0.25	0 0.000,5 0.001	0- 1.5 0- 1.5 0- 1.5	12	23

TABLE 1

BENDING-TORSION FLUTTER (Continued)						
x_a	x_o	r_a^2	δ/μ	ω_h/ω_a	Table No.	Page No.
0	0.50	0.09	0 0.000,5 0.001	0- 1.5 0- 1.5 0- 1.5	13	24
		0.16	0 0.000,5 0.001	0- 1.5 0- 1.5 0- 1.5	14	25
		0.25	0 0.000,5 0.001	0- 1.5 0- 1.5 0- 1.5	15	26
0.1	0.35	0.09	0 0.000,5 0.001	0- 1.5 0- 1.5 0- 1.5	16	27
		0.16	0 0.000,5 0.001	0- 1.5 0- 1.5 0- 1.5	17	28
		0.25	0 0.000,5 0.001	0- 1.5 0- 1.5 0- 1.5	18	29
	0.4	0.09	0 0.000,5 0.001	0- 1.5 0- 1.5 0- 1.5	19	30
		0.16	0 0.000,5 0.001	0- 1.5 0- 1.5 0- 1.5	20	31
		0.25	0 0.000,5 0.001	0- 1.5 0- 1.5 0- 1.5	21	32
		0.36	0	0- 0.7	22	33

TABLE 1

BENDING-TORSION FLUTTER (Continued)						
x_a	x_o	r_a^2	δ/μ	ω_h/ω_a	Table No.	Page No.
0.1	0.45	0.09	0 0.000,5 0.001	0- 1.5 0- 1.5 0- 1.5	23	34
		0.16	0 0.000,5 0.001	0- 1.5 0- 1.5 0- 1.5	24	35
		0.25	0 0.000,5 0.001	0- 1.5 0- 1.5 0- 1.5	25	36
		0.36	0	0- 0.7	26	37
	0.5	0.09	0 0.000,5 0.001	0- 1.5 0- 1.5 0- 1.5	27	38
		0.16	0 0.000,5 0.001	0- 1.5 0- 1.5 0- 1.5	28	39
		0.25	0 0.000,5 0.001	0- 1.5 0- 1.5 0- 1.5	29	40
		0.36	0	0- 0.7	30	41
	0.55	0.09	0	0	31	42
		0.16	0	0	32	43
		0.25	0	0	33	44
		0.36	0	0	34	45

TABLE 1

BENDING-TORSION FLUTTER (Continued)						
x_a	x_o	r_a^2	δ/μ	ω_h/ω_a	Table No.	Page No.
0.2	0.35	0.09	0 0.000,5 0.001	0 - 0.7 0.3- 0.7 0.3- 0.7	35	46
		0.16	0 0.000,5 0.001	0 - 0.7 0.3- 0.7 0.3- 0.7	36	47
		0.25	0 0.000,5 0.001	0 - 0.7 0.3- 0.7 0.3- 0.7	37	48
		0.36	0	0 - 0.7	38	49
	0.40	0.09	0 0.000,5 0.001	0 - 0.7 0 - 0.7 0 - 0.7	39	50
		0.16	0 0.000,5 0.001	0 - 0.7 0 - 0.7 0 - 0.7	40	51
		0.25	0 0.000,5 0.001	0 - 0.7 0 - 0.7 0 - 0.7	41	52
		0.36	0	0 - 0.7	42	53
	0.45	0.09	0 0.000,5 0.001	0 - 0.7 0 - 0.7 0 - 0.7	43	54
		0.16	0 0.000,5 0.001	0 - 0.7 0 - 0.7 0 - 0.7	44	55
		0.25	0 0.000,5 0.001	0 - 0.7 0 - 0.7 0 - 0.7	45	56
		0.36	0	0 - 0.7	46	57

TABLE 1

BENDING-AILERON							
x_1	r_β^2	x_β	δ/μ	μM	$\frac{\omega_\beta}{\omega_h}$	Table No.	Page No.
0.8	0.001,96	0	0 0.001	40-400	0- 1.0	51	62
		0.01	0 0.001	40-400	0- 1.0	52	63
		0.014	0 0.001	40-400	0- 1.0	53	64
0.8	0.003,24	0	0 0.001	40- 400	0- 1.0	54	65
		0.01	0 0.001	40- 400	0- 1.0	55	66
		0.014	0 0.001	40- 400	0- 1.0	56	67

TABLE 2

$\left(\frac{\omega_h}{\omega_a}\right)$	$\frac{\delta/\mu}{\mu M}$	40	60	80	120	180	240	320	400	500	600
0	0 0.0005 0.001	*	*	*	*	*	*	*	*	*	*
		*	*	*	*	*	*	*	*	*	23.870
0.3	0 0.0005 0.001	*	*	*	*	*	*	*	*	*	*
		*	*	*	*	*	*	*	*	*	25.994
0.5	0 0.0005 0.001	*	*	*	*	*	*	*	*	*	*
		*	*	*	*	*	*	*	*	*	27.656
0.7	0 0.0005 0.001	*	*	*	*	*	*	*	*	*	*
		*	*	*	*	*	*	*	*	*	33.061
0.8	0 0.0005 0.001	-	-	-	-	-	-	-	-	-	*
		-	-	-	-	-	-	-	-	-	39.134
0.9	0 0.0005 0.001	-	-	-	-	-	-	-	-	-	-
		-	-	-	-	-	-	-	-	-	52.559
1.0	0 0.0005 0.001	*	*	*	*	*	*	*	*	*	*
		*	*	*	*	*	*	*	*	*	*
1.1	0 0.0005 0.001	9.405 8.247 6.929	21.758 20.530 19.245	29.298 27.581 25.773	40.352 37.366 34.140	52.756 47.345 41.200	62.753 54.368 44.252	74.012 60.843 43.201	83.771 64.867 35.244	94.565 67.041 -	104.246 66.228 -
1.3	0 0.0005 0.001	12.243 11.928 11.605	16.342 15.783 15.205	19.601 18.750 17.858	24.870 23.311 21.629	31.145 28.250 24.972	36.352 31.823 26.386	42.310 35.153 25.659	47.527 37.221 21.398	53.335 38.301 -	58.569 37.787 -
1.5	0 0.0005 0.001	9.800 9.575 9.349	12.678 12.271 11.850	15.013 14.390 13.736	18.834 17.685 16.446	23.425 21.286 18.863	27.254 23.901 19.878	31.646 26.343 19.319	35.499 27.858 16.167	39.793 28.644 -	43.668 28.253 -
$X_a = 0$		$X_0 = 0.35$				$r_a^2 = 0.09$					

(See pages 6 and 7 for explanation of dashes and asterisks)

TABLE 4 $\frac{\mu b \omega_a}{\rho k}$ FOR BENDING-TORSION FLUTTER

$(\frac{b}{a})$	$\frac{b}{a} \mu M$	40	60	80	120	180	240	320	400	500	600
0	0 0.0005 0.001	*	*	*	*	*	*	*	*	*	*
0.3	0 0.0005 0.001	*	*	*	*	*	*	*	*	*	*
0.5	0 0.0005 0.001	*	*	*	*	*	*	*	*	*	*
0.7	0 0.0005 0.001	*	*	*	*	*	*	*	*	*	*
0.8	0 0.0005 0.001	-	-	-	-	-	-	-	-	-	*
0.9	0 0.0005 0.001	-	-	-	-	-	-	-	-	-	-
1.0	0 0.0005 0.001	*	*	*	*	*	*	*	*	*	*
1.1	0 0.0005 0.001	14.786 14.268 13.734	21.557 20.713 19.836	26.660 25.411 24.096	34.683 32.445 30.016	44.058 39.952 35.255	51.762 45.365 37.571	60.527 50.440 36.743	68.175 53.649 30.531	76.669 55.444 -	84.312 54.887 -
1.3	0 0.0005 0.001	10.807 10.573 10.334	13.845 13.424 12.987	16.327 15.682 15.003	20.404 19.217 17.929	25.318 23.106 20.579	29.422 25.953 21.739	34.135 28.640 21.223	38.273 30.339 17.872	42.886 31.275 -	47.050 30.940 -
1.5	0 0.0005 0.001	8.361 8.192 8.019	10.547 10.239 9.919	12.352 11.878 11.379	15.338 14.462 13.511	18.954 17.318 15.449	21.984 19.415 16.295	25.466 21.395 15.903	28.531 22.648 13.423	31.948 23.335 -	35.034 23.083 -
$X_a = 0$		$X_0 = 0.35$					$r_a^2 = 0.16$				

TABLE 5
WADC TN 57-310

$\frac{\mu b \omega}{a}$ FOR BENDING-TORSION FLUTTER

$\frac{\omega_h}{(\omega_a)}$	$\frac{\delta/\mu}{\mu M}$	40	60	80	120	180	240	320	400	500	600
0	0 0.0005 0.001	*	*	*	*	*	*	*	*	*	*
0.3	0 0.0005 0.001	*	*	*	*	*	*	*	*	*	*
0.5	0 0.0005 0.001	*	*	*	*	*	*	*	*	*	*
0.7	0 0.0005 0.001	*	*	*	*	*	*	*	*	*	*
0.8	0 0.0005 0.001	-	-	-	-	-	-	-	-	-	*
0.9	0 0.0005 0.001	-	-	-	-	-	-	-	-	-	-
1.0	0 0.0005 0.001	*	*	*	*	*	*	*	*	*	*
1.1	0 0.0005 0.001	14.729 14.333 13.927	19.968 19.293 18.591	24.093 23.082 22.014	30.725 28.898 26.902	38.592 35.223 31.334	45.108 39.845 33.352	52.553 44.230 32.727	59.067 47.049 27.474	66.316 48.694 -	72.847 48.323 -
1.3	0 0.0005 0.001	9.667 9.477 9.283	12.197 11.853 11.496	14.286 13.758 13.201	17.741 16.767 15.704	21.925 20.107 18.010	25.430 22.573 19.055	29.461 24.924 18.681	33.004 26.437 15.842	36.958 27.313 -	40.528 27.094 -
1.5	0 0.0005 0.001	7.386 7.248 7.106	9.224 8.972 8.710	10.753 10.365 9.954	13.293 12.574 11.789	16.380 15.035 13.483	18.972 16.855 14.251	21.957 18.593 13.969	24.581 19.711 11.867	27.512 20.358 -	30.160 20.193 -
$X_a = 0$		$X_0 = 0.35$				$r_a^2 = 0.25$					

TABLE 6 $\frac{\mu b \omega_a}{\alpha}$ FOR BENDING-TORSION FLUTTER
WADC TN 57-310

$\left(\frac{\omega_h}{\omega_g}\right)$	$\frac{8/\mu}{\mu M}$	40	60	80	120	180	240	320	400	500	600
0	0 0.0005 0.001	*	*	*	*	*	*	*	*	*	*
0.3	0 0.0005 0.001	*	*	*	*	*	*	*	*	*	*
0.5	0 0.0005 0.001	*	*	*	*	*	*	*	*	*	*
0.7	0 0.0005 0.001	*	*	*	*	*	*	*	*	*	*
0.8	0 0.0005 0.001	*	*	*	*	*	*	*	*	*	*
0.9	0 0.0005 0.001	*	*	*	*	*	*	*	*	*	*
1.0	0 0.0005 0.001	*	*	*	*	*	*	*	*	*	*
1.1	0 0.0005 0.001	*	*	*	*	*	*	*	*	*	*
1.3	0 0.0005 0.001	*	*	*	*	*	*	*	*	*	*
1.5	0 0.0005 0.001	*	*	*	*	*	*	*	*	*	*
$X_a = 0$		$X_0 = 0.4$						$r_a^2 = 0.09$			

TABLE 7 $\frac{\mu b \omega_g}{\sigma}$ FOR BENDING-TORSION FLUTTER
WADC TN 57-310

$\frac{b}{a}$	$\frac{b}{a} \mu M$	40	60	80	120	180	240	320	400	500	600
0	0 0.0005 0.001	* * *	* * *	* * *	* * *	* * *	* * *	* * *	* * 15.212	* * 27.373	* * 38.498
0.3	0 0.0005 0.001	* - -	* - -	* - -	* - -	* - -	* - -	* - -	* - 13.019	* - 23.598	* - 33.413
0.5	0 0.0005 0.001	* - -	* - -	* - -	* - -	* - -	* - -	* - -	* - 14.259	* - 25.955	* - 36.782
0.7	0 0.0005 0.001	* - -	* - -	* - -	* - -	* - -	* - -	* - -	* - 17.026	* - 31.350	* - 44.532
0.8	0 0.0005 0.001	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - 19.845	* - 37.118	* - 52.891
0.9	0 0.0005 0.001	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - 25.479	- - 50.277	- - 72.357
1.0	0 0.0005 0.001	* * *	* * *	* * *	* * *	* * *	* * *	* * *	* * *	* * *	* * *
1.1	0 0.0005 0.001	9.061 8.032 6.856	15.880 14.540 13.065	20.549 18.673 16.580	27.611 24.374 20.589	35.673 29.809 22.250	42.223 33.066 19.405	49.629 34.983 -	56.066 34.459 -	63.196 29.996 -	69.599 18.240 -
1.3	0 0.0005 0.001	8.522 8.185 7.834	11.152 10.562 9.933	13.272 12.377 11.402	16.723 15.084 13.209	20.855 17.792 13.949	24.294 19.448 12.515	28.236 20.419 3.308	31.691 20.117 -	35.540 17.763 -	39.011 11.879 -
1.5	0 0.0005 0.001	6.726 6.489 6.242	8.591 8.166 7.715	10.118 9.468 8.762	12.630 11.430 10.061	15.660 13.407 10.590	18.192 14.618 9.540	21.101 15.328 3.204	23.654 15.102 -	26.502 13.367 -	29.073 9.067 -
$X_a = 0$		$X_0 = 0.4$				$r_a^2 = 0.16$					

TABLE 8

 $\frac{\mu b^2}{a^3}$ FOR BENDING-TORSION FLUTTER

$\left(\frac{\omega_h}{\omega_g}\right)$	$\frac{8/\mu}{\mu M}$	40	60	80	120	180	240	320	400	500	600
0	0 0.0005 0.001	*	*	*	*	*	*	*	*	*	*
0.3	0 0.0005 0.001	*	*	*	*	*	*	*	*	*	*
0.5	0 0.0005 0.001	*	*	*	*	*	*	*	*	*	*
0.7	0 0.0005 0.001	*	*	*	*	*	*	*	*	*	*
0.8	0 0.0005 0.001	*	*	*	*	*	*	*	*	*	*
0.9	0 0.0005 0.001	*	*	*	*	*	*	*	*	*	*
1.0	0 0.0005 0.001	*	*	*	*	*	*	*	*	*	*
1.1	0 0.0005 0.001	10.617 9.960 9.256	15.490 14.461 13.346	19.161 17.662 16.004	24.931 22.273 19.180	31.673 26.792 20.521	37.213 29.542 18.173	43.517 31.185 -	49.016 30.760 -	55.123 26.992 -	60.619 17.188 -
1.3	0 0.0005 0.001	7.807 7.534 7.249	9.984 9.496 8.975	11.764 11.019 10.206	14.691 13.317 11.740	18.220 15.639 12.383	21.169 17.073 11.174	24.556 17.928 3.682	27.529 17.689 -	30.845 15.682 -	33.838 10.641 -
1.5	0 0.0005 0.001	6.044 5.849 5.645	7.609 7.255 6.879	8.904 8.359 7.767	11.046 10.037 8.881	13.643 11.741 9.347	15.819 12.794 8.459	18.323 13.423 3.157	20.524 13.245 -	22.980 11.763 -	25.198 8.064 -
$X_a = 0$		$X_0 = 0.4$					$r_a^2 = 0.25$				

TABLE 9 $\frac{\mu b \omega_g}{\rho}$ FOR BENDING-TORSION FLUTTER
WADC TN 57-310

$\left(\frac{\omega_h}{\omega_g}\right)$	$\frac{\delta/\mu}{\mu M}$	40	60	80	120	180	240	320	400	500	600
0	0 0.0005 0.001	*	*	*	*	*	*	*	*	*	*
		-	-	-	-	-	-	-	10.459	18.791	26.176
		-	-	-	-	3.988	12.101	20.479	28.423	38.216	48.013
0.3	0 0.0005 0.001	*	*	*	*	*	*	*	*	*	*
		-	-	-	-	-	-	-	10.862	19.644	27.402
		-	-	-	-	3.899	12.599	21.420	29.764	40.042	50.318
0.5	0 0.0005 0.001	*	*	*	*	*	*	*	*	*	*
		-	-	-	-	-	-	-	11.691	21.494	30.085
		-	-	-	-	3.450	13.650	23.471	32.703	44.054	55.392
0.7	0 0.0005 0.001	*	*	*	*	*	*	*	*	*	*
		-	-	-	-	-	-	-	13.251	25.590	36.160
		-	-	-	-	-	15.790	28.055	39.393	53.253	67.062
0.8	0 0.0005 0.001	*	*	*	*	*	*	*	*	*	*
		-	-	-	-	-	-	-	14.208	29.707	42.533
		-	-	-	-	-	17.540	32.753	46.470	63.119	79.648
0.9	0 0.0005 0.001	*	*	*	*	*	*	*	*	*	*
		-	-	-	-	-	-	-	10.594	37.577	56.397
		-	-	-	-	-	17.903	42.280	62.233	85.811	108.961
1.0	0 0.0005 0.001	*	*	*	*	*	*	*	*	*	*
		-	-	-	-	-	-	-	-	-	-
		-	-	-	-	-	-	-	-	-	-
1.1	0 0.0005 0.001	*	*	*	*	*	*	*	*	*	*
		-	-	-	-	-	-	-	45.562	52.381	58.408
		-	-	-	-	24.632	31.740	39.264	-	-	-
1.3	0 0.0005 0.001	2.860	6.988	9.459	13.068	17.109	20.363	24.026	27.200	30.710	33.858
		-	5.260	7.184	9.217	9.922	8.235	-	-	-	-
		-	2.562	3.711	-	-	-	-	-	-	-
1.5	0 0.0005 0.001	4.026	6.216	7.815	10.294	13.163	15.511	18.175	20.496	23.071	25.386
		3.321	5.185	6.330	7.642	8.106	6.976	-	-	-	-
		2.421	3.889	4.362	3.260	-	-	-	-	-	-
$X_a = 0$		$X_0 = 0.45$					$r_a^2 = 0.09$				

TABLE 10 $\frac{\mu b \omega_g}{\sigma k_e}$ FOR BENDING-TORSION FLUTTER
WADC TN 57-310

$\left(\frac{\omega_h}{\omega_n}\right)$	$\frac{\delta/\mu}{\mu M}$	40	60	80	120	180	240	320	400	500	600
0	0 0.0005 0.001	*	*	*	*	*	*	*	*	*	*
		-	-	-	-	-	-	-	8.489	15.268	21.291
		-	-	-	-	3.235	9.830	16.665	23.172	31.234	39.344
0.3	0 0.0005 0.001	*	*	*	*	*	*	*	*	*	*
		-	-	-	-	-	-	-	8.844	15.975	22.299
		-	-	-	-	3.243	10.258	17.444	24.274	32.731	41.236
0.5	0 0.0005 0.001	*	*	*	*	*	*	*	*	*	*
		-	-	-	-	-	-	-	9.597	17.520	24.510
		-	-	-	-	3.151	11.178	19.148	26.694	36.025	45.403
0.7	0 0.0005 0.001	*	*	*	*	*	*	*	*	*	*
		-	-	-	-	-	-	-	11.154	20.993	29.549
		-	-	-	-	1.856	13.153	23.002	32.228	43.594	54.999
0.8	0 0.0005 0.001	-	-	-	-	-	-	-	-	*	*
		-	-	-	-	-	-	-	12.486	24.589	34.900
		-	-	-	-	-	15.008	27.037	38.134	51.743	65.367
0.9	0 0.0005 0.001	-	-	-	-	-	-	-	-	-	-
		-	-	-	-	-	-	-	13.350	32.128	46.900
		-	-	-	-	-	17.679	35.746	51.557	70.640	89.656
1.0	0 0.0005 0.001	*	*	*	*	*	*	*	*	*	*
		*	*	*	*	*	*	*	*	*	*
		*	*	*	*	*	*	*	*	*	*
1.1	0 0.0005 0.001	-	3.565	9.999	16.568	23.158	28.250	39.264	45.562	52.381	58.408
		-	-	4.385	9.558	11.010	7.496	-	-	-	-
		-	-	-	-	-	-	-	-	-	-
1.3	0 0.0005 0.001	4.841	7.071	8.750	11.387	14.469	17.001	19.881	22.394	25.185	27.696
		4.157	6.004	7.188	8.568	9.061	7.863	-	-	-	-
		3.334	4.697	5.163	4.073	-	-	-	-	-	-
1.5	0 0.0005 0.001	4.234	5.709	6.874	8.750	10.980	12.867	14.939	16.787	18.844	20.698
		3.810	4.987	5.786	6.742	7.086	6.242	-	-	-	-
		3.331	4.137	4.429	3.741	-	-	-	-	-	-
$X_a = 0$		$X_0 = 0.45$					$r_a^2 = 0.16$				

TABLE 11 $\frac{\mu b c}{\rho$ FOR BENDING-TORSION FLUTTER
WADC TN 57-310

$(\frac{\omega h}{\omega_a})$	$\frac{\mu M}{8/\mu}$	40	60	80	120	180	240	320	400	500	600
0	0 0.0005 0.001	* - -	* - -	* - -	* - -	* - 2.819	* - 8.577	* - 14.565	* 7.401 20.287	* 13.325 27.406	* 18.601 34.603
0.3	0 0.0005 0.001	* - -	* - -	* - -	* - -	* - 2.858	* - 8.961	* - 15.252	* 7.722 21.256	* 13.949 28.722	* 19.486 36.269
0.5	0 0.0005 0.001	* - -	* - -	* - -	* - -	* - 2.877	* - 9.790	* - 16.755	* 8.410 23.384	* 15.313 31.619	* 21.428 39.938
0.7	0 0.0005 0.001	* - -	* - -	* - -	* - -	* - 2.395	* - 11.606	* - 20.173	* 9.882 28.260	* 18.402 38.281	* 25.870 48.391
0.8	0 0.0005 0.001	- - -	- - -	- - -	- - -	- - -	- - 13.392	- - 23.78	- 11.251 33.486	- 21.641 45.466	- 30.612 57.532
0.9	0 0.0005 0.001	- - -	- - -	- - -	- - -	- - -	- - 16.539	- - 31.769	- 13.120 45.463	- 28.665 62.185	- 41.380 78.958
1.0	0 0.0005 0.001	* * *	* * *	* * *	* * *	* * *	* * *	* * *	* * *	* * *	* * *
1.1	0 0.0005 0.001	- - -	7.644 4.902 -	11.147 7.930 1.117	15.998 10.823 -	21.294 11.802 -	25.514 9.460 -	30.237 - -	34.316 - -	38.817 - -	42.848 - -
1.3	0 0.0005 0.001	4.899 4.397 3.828	6.636 5.788 4.785	8.005 6.730 5.132	10.205 7.856 4.317	12.816 8.264 -	14.979 7.275 -	17.450 - -	19.613 - -	22.019 - -	24.187 - -
1.5	0 0.0005 0.001	4.011 3.675 3.304	5.210 4.618 3.932	6.181 5.275 4.165	7.767 6.074 3.615	9.670 6.364 -	11.256 5.656 -	13.074 1.224 -	14.669 - -	16.446 - -	18.049 - -
$X_a = 0$		$X_0 = 0.45$				$r_a^2 = 0.25$					

TABLE 12 $\frac{\mu b \omega_a}{g}$ FOR BENDING-TORSION FLUTTER
WADC TN 57-310

$\left(\frac{\omega_h}{\omega_a}\right)$	$\frac{\delta/\mu}{\mu M}$	40	60	80	120	180	240	320	400	500	600
0	0 0.0005 0.001	* 1.439 2.975	* 3.247 5.079	* 4.733 7.037	* 7.502 10.830	* 11.511 16.425	* 15.466 21.983	* 20.710 29.374	* 25.939 36.753	* 32.465 45.970	* 38.984 55.183
0.3	0 0.0005 0.001	* - 2.707	* 3.030 5.094	* 4.713 7.213	* 7.710 11.248	* 11.967 17.151	* 16.140 22.996	* 21.656 30.757	* 27.149 38.502	* 33.999 48.171	* 40.840 57.835
0.5	0 0.0005 0.001	* - -	* 2.057 4.960	* 4.477 7.500	* 8.077 12.112	* 12.920 18.714	* 17.586 25.202	* 23.714 33.788	* 29.794 42.343	* 37.364 53.014	* 44.916 63.672
0.7	0 0.0005 0.001	* - -	* - 3.010	* 1.519 7.463	* 8.296 13.746	* 14.781 22.108	* 20.688 30.141	* 28.293 40.678	* 35.769 51.128	* 45.030 64.134	* 54.243 77.107
0.8	0 0.0005 0.001	- - -	- - -	- - 5.389	- 6.891 14.773	- 16.117 25.377	- 23.599 35.215	- 32.944 47.957	- 42.005 60.512	- 53.158 76.095	- 64.210 91.607
0.9	0 0.0005 0.001	- - -	- - -	- - -	- - 11.341	- 14.328 30.677	- 27.756 45.595	- 42.137 64.045	- 55.385 81.868	- 71.319 103.796	- 86.906 125.590
1.0	0 0.0005 0.001	* * *	* * *	* * *	* * *	* * *	* * *	* * *	* * *	* * *	* * *
1.1	0 0.0005 0.001	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -
1.3	0 0.0005 0.001	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -
1.5	0 0.0005 0.001	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -
$X_a = 0$		$X_0 = 0.5$					$r_a^2 = 0.09$				

TABLE 13 $\frac{\mu b \omega_a}{\rho}$ FOR BENDING-TORSION FLUTTER
WADC TN 57-310

$\left(\frac{\omega_h}{\omega_a}\right)$	$\frac{\delta/\mu}{\mu M}$	40	60	80	120	180	240	320	400	500	600
0	0 0.0005 0.001	* 1.165 2.409	* 2.629 4.112	* 3.832 5.697	* 6.074 8.768	* 9.320 13.298	* 12.522 17.799	* 16.768 23.782	* 21.001 29.757	* 26.284 37.219	* 31.563 44.678
0.3	0 0.0005 0.001	* 0.678 2.312	* 2.561 4.189	* 3.886 5.886	* 6.286 9.136	* 9.717 13.905	* 13.088 18.632	* 17.549 24.912	* 21.993 31.180	* 27.536 39.006	* 33.073 46.828
0.5	0 0.0005 0.001	* - 1.876	* 2.234 4.282	* 3.919 6.251	* 6.706 9.917	* 10.565 15.222	* 14.315 20.455	* 19.256 27.392	* 24.167 34.309	* 30.286 42.941	* 36.393 51.565
0.7	0 0.0005 0.001	* - -	* - 3.913	* 3.303 6.772	* 7.382 11.538	* 12.351 18.151	* 17.024 24.584	* 23.106 33.061	* 29.115 41.489	* 36.578 51.992	* 44.014 62.474
0.8	0 0.0005 0.001	- - -	- - 0.451	- - 6.599	- 7.464 12.937	- 13.955 21.118	- 19.733 28.916	- 27.120 39.109	- 34.354 49.201	- 43.305 61.755	- 52.200 74.270
0.9	0 0.0005 0.001	- - -	- - -	- - -	- - 13.952	- 15.674 26.925	- 24.807 38.309	- 35.673 52.807	- 46.018 66.965	- 58.641 84.515	- 71.103 101.947
1.0	0 0.0005 0.001	* * *	* * *	* * *	* * *	* * *	* * *	* * *	* * *	* * *	* * *
1.1	0 0.0005 0.001	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -
1.3	0 0.0005 0.001	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -
1.5	0 0.0005 0.001	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -
$X_a = 0$		$X_0 = 0.5$				$r_a^2 = 0.16$					

TABLE 14

 $\frac{\mu b \omega_a}{c}$

FOR BENDING-TORSION FLUTTER

$\frac{\omega_h}{(\omega_a)}$	$\frac{\delta/\mu}{\mu M}$	40	60	80	120	180	240	320	400	500	600
0	$\begin{matrix} 0 \\ 0.0005 \\ 0.001 \end{matrix}$	$\begin{matrix} * \\ 1.014 \\ 2.095 \end{matrix}$	$\begin{matrix} * \\ 2.287 \\ 3.577 \end{matrix}$	$\begin{matrix} * \\ 3.333 \\ 4.956 \end{matrix}$	$\begin{matrix} * \\ 5.284 \\ 7.628 \end{matrix}$	$\begin{matrix} * \\ 8.107 \\ 11.568 \end{matrix}$	$\begin{matrix} * \\ 10.893 \\ 15.483 \end{matrix}$	$\begin{matrix} * \\ 14.587 \\ 20.688 \end{matrix}$	$\begin{matrix} * \\ 18.269 \\ 25.886 \end{matrix}$	$\begin{matrix} * \\ 22.865 \\ 32.377 \end{matrix}$	$\begin{matrix} * \\ 27.457 \\ 38.866 \end{matrix}$
0.3	$\begin{matrix} 0 \\ 0.0005 \\ 0.001 \end{matrix}$	$\begin{matrix} * \\ 0.733 \\ 2.058 \end{matrix}$	$\begin{matrix} * \\ 2.270 \\ 3.670 \end{matrix}$	$\begin{matrix} * \\ 3.409 \\ 5.139 \end{matrix}$	$\begin{matrix} * \\ 5.485 \\ 7.960 \end{matrix}$	$\begin{matrix} * \\ 8.464 \\ 12.103 \end{matrix}$	$\begin{matrix} * \\ 11.394 \\ 16.214 \end{matrix}$	$\begin{matrix} * \\ 15.272 \\ 21.675 \end{matrix}$	$\begin{matrix} * \\ 19.137 \\ 27.127 \end{matrix}$	$\begin{matrix} * \\ 23.958 \\ 33.934 \end{matrix}$	$\begin{matrix} * \\ 28.774 \\ 40.738 \end{matrix}$
0.5	$\begin{matrix} 0 \\ 0.0005 \\ 0.001 \end{matrix}$	$\begin{matrix} * \\ - \\ 1.854 \end{matrix}$	$\begin{matrix} * \\ 2.134 \\ 3.828 \end{matrix}$	$\begin{matrix} * \\ 3.521 \\ 5.509 \end{matrix}$	$\begin{matrix} * \\ 5.900 \\ 8.672 \end{matrix}$	$\begin{matrix} * \\ 9.232 \\ 13.270 \end{matrix}$	$\begin{matrix} * \\ 12.483 \\ 17.815 \end{matrix}$	$\begin{matrix} * \\ 16.773 \\ 23.844 \end{matrix}$	$\begin{matrix} * \\ 21.041 \\ 29.857 \end{matrix}$	$\begin{matrix} * \\ 26.360 \\ 37.363 \end{matrix}$	$\begin{matrix} * \\ 31.670 \\ 44.862 \end{matrix}$
0.7	$\begin{matrix} 0 \\ 0.0005 \\ 0.001 \end{matrix}$	$\begin{matrix} * \\ - \\ - \end{matrix}$	$\begin{matrix} * \\ 0.078 \\ 3.857 \end{matrix}$	$\begin{matrix} * \\ 3.398 \\ 6.163 \end{matrix}$	$\begin{matrix} * \\ 6.672 \\ 10.197 \end{matrix}$	$\begin{matrix} * \\ 10.895 \\ 15.891 \end{matrix}$	$\begin{matrix} * \\ 14.919 \\ 21.458 \end{matrix}$	$\begin{matrix} * \\ 20.180 \\ 28.812 \end{matrix}$	$\begin{matrix} * \\ 25.390 \\ 36.130 \end{matrix}$	$\begin{matrix} * \\ 31.868 \\ 45.255 \end{matrix}$	$\begin{matrix} * \\ 38.327 \\ 54.366 \end{matrix}$
0.8	$\begin{matrix} 0 \\ 0.0005 \\ 0.001 \end{matrix}$	$\begin{matrix} - \\ - \\ - \end{matrix}$	$\begin{matrix} - \\ - \\ 2.960 \end{matrix}$	$\begin{matrix} - \\ 2.006 \\ 6.445 \end{matrix}$	$\begin{matrix} - \\ 7.125 \\ 11.626 \end{matrix}$	$\begin{matrix} - \\ 12.488 \\ 18.596 \end{matrix}$	$\begin{matrix} - \\ 17.412 \\ 25.314 \end{matrix}$	$\begin{matrix} - \\ 23.769 \\ 34.135 \end{matrix}$	$\begin{matrix} - \\ 30.023 \\ 42.884 \end{matrix}$	$\begin{matrix} - \\ 37.779 \\ 53.780 \end{matrix}$	$\begin{matrix} - \\ 45.496 \\ 64.650 \end{matrix}$
0.9	$\begin{matrix} 0 \\ 0.0005 \\ 0.001 \end{matrix}$	$\begin{matrix} - \\ - \\ - \end{matrix}$	$\begin{matrix} - \\ - \\ - \end{matrix}$	$\begin{matrix} - \\ 2.822 \\ - \end{matrix}$	$\begin{matrix} - \\ 5.024 \\ 13.638 \end{matrix}$	$\begin{matrix} - \\ 14.996 \\ 24.219 \end{matrix}$	$\begin{matrix} - \\ 22.459 \\ 33.876 \end{matrix}$	$\begin{matrix} - \\ 31.642 \\ 46.313 \end{matrix}$	$\begin{matrix} - \\ 40.502 \\ 58.541 \end{matrix}$	$\begin{matrix} - \\ 51.367 \\ 73.721 \end{matrix}$	$\begin{matrix} - \\ 62.137 \\ 88.804 \end{matrix}$
1.0	$\begin{matrix} 0 \\ 0.0005 \\ 0.001 \end{matrix}$	$\begin{matrix} * \\ * \\ * \end{matrix}$	$\begin{matrix} * \\ * \\ * \end{matrix}$	$\begin{matrix} * \\ * \\ * \end{matrix}$	$\begin{matrix} * \\ * \\ * \end{matrix}$	$\begin{matrix} * \\ * \\ * \end{matrix}$	$\begin{matrix} * \\ * \\ * \end{matrix}$	$\begin{matrix} * \\ * \\ * \end{matrix}$	$\begin{matrix} * \\ * \\ * \end{matrix}$	$\begin{matrix} * \\ * \\ * \end{matrix}$	$\begin{matrix} * \\ * \\ * \end{matrix}$
1:1	$\begin{matrix} 0 \\ 0.0005 \\ 0.001 \end{matrix}$	$\begin{matrix} - \\ - \\ - \end{matrix}$	$\begin{matrix} - \\ - \\ - \end{matrix}$	$\begin{matrix} - \\ - \\ - \end{matrix}$	$\begin{matrix} - \\ - \\ - \end{matrix}$	$\begin{matrix} - \\ - \\ - \end{matrix}$	$\begin{matrix} - \\ - \\ - \end{matrix}$	$\begin{matrix} - \\ - \\ - \end{matrix}$	$\begin{matrix} - \\ - \\ - \end{matrix}$	$\begin{matrix} - \\ - \\ - \end{matrix}$	$\begin{matrix} - \\ - \\ - \end{matrix}$
1.3	$\begin{matrix} 0 \\ 0.0005 \\ 0.001 \end{matrix}$	$\begin{matrix} - \\ - \\ - \end{matrix}$	$\begin{matrix} - \\ - \\ - \end{matrix}$	$\begin{matrix} - \\ - \\ - \end{matrix}$	$\begin{matrix} - \\ - \\ - \end{matrix}$	$\begin{matrix} - \\ - \\ - \end{matrix}$	$\begin{matrix} - \\ - \\ - \end{matrix}$	$\begin{matrix} - \\ - \\ - \end{matrix}$	$\begin{matrix} - \\ - \\ - \end{matrix}$	$\begin{matrix} - \\ - \\ - \end{matrix}$	$\begin{matrix} - \\ - \\ - \end{matrix}$
1.5	$\begin{matrix} 0 \\ 0.0005 \\ 0.001 \end{matrix}$	$\begin{matrix} - \\ - \\ - \end{matrix}$	$\begin{matrix} - \\ - \\ - \end{matrix}$	$\begin{matrix} - \\ - \\ - \end{matrix}$	$\begin{matrix} - \\ - \\ - \end{matrix}$	$\begin{matrix} - \\ - \\ - \end{matrix}$	$\begin{matrix} - \\ - \\ - \end{matrix}$	$\begin{matrix} - \\ - \\ - \end{matrix}$	$\begin{matrix} - \\ - \\ - \end{matrix}$	$\begin{matrix} - \\ - \\ - \end{matrix}$	$\begin{matrix} - \\ - \\ - \end{matrix}$
$x_a = 0$		$x_0 = 0.5$					$r_a^2 = 0.25$				

TABLE 15 $\sqrt{\frac{\mu b}{\rho A}}$ FOR BENDING-TORSION FLUTTER
WADC TN 57-310

$\frac{U_b}{(\frac{b}{a})}$	$\frac{U_b}{\mu m}$	40	60	80	120	180	240	320	400	500	600
0	0 0.0005 0.001	*	*	*	*	*	*	*	*	*	*
0.3	0 0.0005 0.001	*	*	*	*	*	*	*	*	*	*
0.5	0 0.0005 0.001	*	*	*	*	*	*	*	*	*	*
0.7	0 0.0005 0.001	*	*	*	*	*	*	*	*	*	*
0.8	0 0.0005 0.001	7.277 7.890	9.899 10.904	12.152 13.594	16.154 18.554	21.576 25.537	26.674 32.276	33.220 41.069	39.604 49.729	47.446 60.425	55.187 71.012
0.9	0 0.0005 0.001	10.657 11.122 11.567	13.593 14.407 15.174	15.999 17.219 18.349	19.959 22.122 24.066	24.739 28.567 31.872	28.734 34.454 39.217	33.322 41.834 48.610	37.351 48.873 57.724	41.846 57.385 68.870	45.903 65.671 79.881
1.0	0 0.0005 0.001	13.475 13.841 14.194	16.993 17.640 18.255	19.899 20.873 21.782	24.705 26.442 28.014	30.528 33.615 36.288	35.404 40.025 43.861	41.016 47.889 53.315	45.950 55.226 62.257	51.448 63.992 72.932	56.415 72.357 83.333
1.1	0 0.0005 0.001	15.099 15.373 15.635	18.941 19.424 19.878	22.125 22.851 23.518	27.405 28.693 29.827	33.814 36.086 37.960	39.188 42.564 45.167	45.373 50.346 53.831	50.812 57.470 61.677	56.883 65.713 70.538	62.366 73.385 78.487
1.3	0 0.0005 0.001	15.616 15.797 15.969	19.530 19.847 20.136	22.782 23.253 23.669	28.181 29.005 29.681	34.740 36.166 37.202	40.244 42.323 43.631	46.582 49.562 51.025	52.156 56.031 57.334	58.379 63.315 63.833	64.000 69.881 68.707
1.5	0 0.0005 0.001	14.650 14.694 14.730	18.263 18.330 18.376	21.271 21.361 21.408	26.274 26.406 26.421	32.358 32.531 32.392	37.468 37.640 37.185	43.353 43.442 42.256	48.530 48.419 46.060	54.312 53.756 49.083	59.535 58.284 49.830
		12.902 12.879 12.851	16.057 16.004 15.936	18.687 18.596 18.474	23.064 22.871 22.595	28.391 27.985 27.354	32.866 32.173 31.017	38.021 36.825 34.662	42.557 40.710 37.102	47.623 44.748 38.472	53.200 48.009 37.546
$X_a = 0.1$		$X_0 = 0.35$					$r_a^2 = 0.09$				

TABLE 16

 $\frac{\mu b c}{a}$

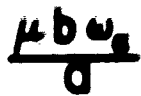
FOR BENDING-TORSION FLUTTER

$\frac{b}{h}$	$\frac{\delta/\mu}{\mu M}$	40	60	80	120	180	240	320	400	500	600
0	0 0.0005 0.001	*	*	*	*	*	*	*	*	*	*
0.3	0 0.0005 0.001	*	*	*	*	*	*	*	*	*	*
0.5	0 0.0005 0.001	*	*	*	*	*	*	*	*	*	*
0.7	0 0.0005 0.001	*	*	*	*	*	*	*	*	*	*
0.8	0 0.0005 0.001	8.269 8.758 9.220	10.679 11.522 12.302	12.638 13.890 15.026	15.844 18.042 19.968	19.699 23.555 26.778	22.914 28.637 33.223	26.603 35.054 41.501	29.838 41.216 49.514	33.446 48.691 59.262	36.701 55.983 68.754
0.9	0 0.0005 0.001	12.970 13.313 13.643	16.373 16.978 17.548	19.182 20.089 20.932	23.826 25.438 26.886	29.450 32.305 34.748	34.159 38.422 41.914	39.578 45.911 50.807	44.341 52.896 59.173	49.654 61.130 69.138	54.457 69.007 78.762
1.0	0 0.0005 0.001	16.208 16.415 16.613	20.298 20.662 20.999	23.693 24.235 24.727	29.327 30.281 31.105	36.167 37.838 39.174	41.906 44.372 46.199	48.513 52.117 54.528	54.322 59.116 62.017	60.807 67.119 70.538	66.665 74.496 78.477
1.1	0 0.0005 0.001	17.062 17.128 17.188	21.284 21.392 21.482	24.797 24.950 25.067	30.637 30.887 31.043	37.740 38.137 38.291	43.703 44.236 44.296	50.572 51.249 51.019	56.613 57.378 56.645	63.360 64.135 62.432	69.454 70.111 66.978
1.3	0 0.0005 0.001	14.578 14.505 14.429	18.114 17.971 17.823	21.064 20.838 20.599	25.979 25.548 25.079	31.964 31.143 30.217	36.993 35.694 34.169	42.789 40.723 38.154	47.888 44.912 40.957	53.585 49.267 42.900	58.731 52.836 42.802
1.5	0 0.0005 0.001	11.723 11.628 11.532	14.539 14.359 14.176	16.892 16.611 16.322	20.815 20.288 19.739	25.596 24.610 23.553	29.614 28.075 26.367	34.247 31.831 29.006	38.323 34.882 30.577	42.877 37.943 31.038	46.992 40.321 29.346
$X_a = 0.1$		$X_0 = 0.35$				$r_a^2 = 0.16$					

TABLE 17 $\frac{F_{be}}{q_e}$ FOR BENDING-TORSION FLUTTER
WADC TN 57-310

$(\frac{\omega_n}{\omega_g})$	$\frac{\delta/\mu}{\mu M}$	40	60	80	120	180	240	320	400	500	600
0	0 0.0005 0.001	*	*	*	*	*	*	*	*	*	*
0.3	0 0.0005 0.001	*	*	*	*	*	*	*	*	*	*
0.5	0 0.0005 0.001	*	*	*	*	*	*	*	*	*	*
0.7	0 0.0005 0.001	*	*	*	*	*	*	*	*	*	*
0.8	0 0.0005 0.001	6.315 6.856 7.355	8.318 9.230 10.053	9.925 11.264 12.488	12.536 14.858 16.831	15.656 19.685 22.934	18.249 24.185 28.760	21.221 29.918 36.274	23.823 35.462 43.580	26.723 42.223 52.472	29.337 48.842 61.118
0.9	0 0.0005 0.001	12.051 12.824 13.134	15.798 16.364 16.898	18.516 19.365 20.150	23.008 24.513 25.854	28.446 31.105 33.356	33.001 36.961 40.148	38.241 44.099 48.541	42.843 50.741 56.379	47.979 58.561 65.653	52.617 65.967 74.453
1.0	0 0.0005 0.001	17.181 17.322 17.456	21.488 21.731 21.955	25.065 25.425 25.748	31.005 31.632 32.164	38.222 39.308 40.156	44.278 45.870 47.016	51.251 53.560 55.070	57.383 60.437 62.282	64.230 68.230 70.538	70.415 75.364 78.392
1.1	0 0.0005 0.001	17.590 17.573 17.552	21.898 21.855 21.806	25.488 25.413 25.327	31.462 31.307 31.123	38.732 38.419 38.030	44.838 44.325 43.667	51.874 51.031 49.917	58.063 56.823 55.148	64.976 63.147 60.636	71.221 68.703 65.233
1.3	0 0.0005 0.001	13.151 13.058 12.965	16.302 16.127 15.951	18.936 18.664 18.388	23.328 22.821 22.302	28.681 27.739 26.754	33.182 31.716 30.148	38.371 36.086 33.531	42.936 39.702 35.865	48.038 43.436 37.385	52.646 46.470 37.014
1.5	0 0.0005 0.001	9.939 9.851 9.762	12.296 12.133 11.966	14.269 14.015 13.756	17.562 17.091 16.601	21.580 20.702 19.764	24.958 23.591 22.079	28.855 26.714 24.207	32.284 29.238 25.393	36.115 31.751 25.492	39.578 33.674 23.461
$X_a = 0.1$		$X_0 = 0.35$				$r_a^2 = 0.25$					

TABLE 18



FOR BENDING-TORSION FLUTTER

$\frac{\omega_h}{(\omega_a)}$	$\frac{\delta/\mu}{\mu M}$	40	60	80	120	180	240	320	400	500	600
0	0 0.0005 0.001	*	*	*	*	*	*	*	*	*	*
0.3	0 0.0005 0.001	*	*	*	*	*	*	*	*	*	*
0.5	0 0.0005 0.001	3.316 4.359 5.196	4.789 6.398 7.677	5.905 8.177 9.942	7.664 11.433 14.233	9.723 16.012 20.439	11.417 20.442 26.535	13.345 26.245 34.585	15.027 31.985 42.581	16.896 39.110 52.524	18.578 46.200 62.420
0.7	0 0.0005 0.001	11.122 11.557 11.974	14.048 14.817 15.545	16.462 17.621 18.701	20.453 22.519 24.391	25.284 28.958 32.166	29.330 34.837 39.490	33.983 42.200 48.885	38.072 49.234 58.034	42.635 57.737 69.276	46.755 66.027 80.435
0.8	0 0.0005 0.001	14.125 14.487 14.838	17.720 18.367 18.987	20.700 21.680 22.605	25.541 27.400 29.018	31.639 34.782 37.582	36.667 41.401 45.491	42.455 49.556 55.470	47.542 57.209 65.081	53.223 66.353 76.860	58.353 75.169 88.689
0.9	0 0.0005 0.001	16.223 16.508 16.785	20.280 20.791 21.278	23.652 24.425 25.150	29.250 30.637 31.898	36.056 38.530 40.682	41.766 45.482 48.587	48.337 53.885 58.301	54.121 61.639 67.389	60.589 70.746 78.134	66.431 79.305 88.595
1.0	0 0.0005 0.001	17.072 17.264 17.447	21.296 21.636 21.952	24.811 25.322 25.786	30.654 31.561 32.341	37.760 39.355 40.615	43.726 46.084 47.780	50.598 54.043 56.184	56.643 61.211 63.566	63.393 69.368 71.509	69.491 76.827 77.903
1.1	0 0.0005 0.001	16.816 16.915 17.005	20.946 21.117 21.265	24.387 24.638 24.843	30.111 30.542 30.847	37.076 37.798 38.181	42.925 43.940 44.269	49.663 51.038 51.005	55.591 57.260 56.407	62.211 64.108 61.267	68.192 70.111 63.464
1.3	0 0.0005 0.001	14.761 14.740 14.711	18.355 18.306 18.240	21.353 21.268 21.148	26.344 26.164 25.884	32.420 32.034 31.372	37.525 36.853 35.601	43.408 42.220 39.776	48.583 46.709 42.457	54.364 51.362 43.547	59.586 55.114 41.208
1.5	0 0.0005 0.001	12.533 12.464 12.391	15.569 15.436 15.290	18.103 17.891 17.652	22.324 21.916 21.433	27.465 26.673 25.669	31.785 30.507 28.772	36.764 34.678 31.565	41.145 38.060 32.964	46.038 41.417 32.550	50.459 43.947 28.701
$X_a = 0.1$		$X_0 = 0.4$				$r_a^2 = 0.09$					

TABLE 19 $\frac{F_{de}}{\rho b^3}$ FOR BENDING-TORSION FLUTTER
WADC TN 57-310

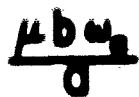
$\frac{b_h}{(b_a)}$	$\frac{\delta/\mu}{\mu M}$	40	60	80	120	180	240	320	400	500	600
0	0 0.0005 0.001	*	*	*	*	*	*	*	*	*	*
		-	-	-	-	-	-	-	8.400	15.106	21.062
		-	-	-	-	3.201	9.726	16.485	22.917	30.880	38.885
0.3	0 0.0005 0.001	*	*	*	*	*	*	*	*	*	*
		-	-	-	-	-	-	-	13.767	19.684	25.431
		-	-	-	-	7.851	13.019	19.546	25.979	34.018	42.108
0.5	0 0.0005 0.001	-	-	-	-	-	-	-	-	-	-
		1.092	1.175 3.698	3.125 5.624	5.893 9.162	9.625 14.263	13.235 19.293	17.985 25.963	22.705 32.616	28.587 40.925	34.459 49.233
0.7	0 0.0005 0.001	7.822 8.269 8.692	9.979 10.759 11.481	11.746 12.911 13.970	14.655 16.711 18.513	18.164 21.782 24.809	21.098 26.475 30.796	24.469 32.418 38.510	27.428 38.142 46.021	30.729 45.100 55.198	33.709 51.904 64.184
0.8	0 0.0005 0.001	11.751 12.097 12.432	14.786 15.402 15.985	17.298 18.225 19.091	21.455 23.111 24.612	26.496 29.442 32.009	30.721 35.136 38.842	35.583 42.167 47.456	39.851 48.793 55.706	44.619 56.685 65.686	48.925 64.293 75.449
0.9	0 0.0005 0.001	15.504 15.763 16.013	19.393 19.854 20.293	22.622 23.320 23.973	27.986 29.233 30.367	34.503 36.726 38.662	39.968 43.306 46.106	46.263 51.245 55.249	51.806 58.561 63.836	57.987 67.116 74.166	63.577 75.207 84.394
1.0	0 0.0005 0.001	17.656 17.791 17.921	22.012 22.251 22.472	25.638 25.995 26.318	31.669 32.299 32.839	39.004 40.107 40.982	45.164 46.790 47.984	52.259 54.634 56.205	58.499 61.655 63.537	65.469 69.620 71.805	71.765 76.909 79.360
1.1	0 0.0005 0.001	17.400 17.413 17.420	21.649 21.664 21.665	25.191 25.205 25.194	31.088 31.093 31.031	38.265 38.233 38.019	44.294 44.190 43.714	51.241 50.976 49.939	57.352 56.842 54.925	64.179 63.225 59.548	70.345 68.772 62.080
1.3	0 0.0005 0.001	13.888 13.793 13.696	17.238 17.059 16.873	20.036 19.755 19.459	24.698 24.170 23.598	30.378 29.382 28.251	35.152 33.581 31.700	40.654 38.158 34.917	45.496 41.893 36.733	50.904 45.647 36.869	55.791 48.550 33.617
1.5	0 0.0005 0.001	10.889 10.781 10.671	13.498 13.297 13.089	15.679 15.366 15.039	19.316 18.731 18.106	23.748 22.653 21.431	27.475 25.756 23.742	31.771 29.054 25.609	35.552 31.646 26.187	39.775 34.104 24.802	43.592 35.813 19.626
$\chi_a = 0.1$		$\chi_0 = 0.4$					$r_a^2 = 0.16$				

TABLE 20
WADC TN 57-310

$\frac{F_{be}}{\rho}$ FOR BENDING-TORSION FLUTTER

$\left(\frac{bh}{w_a}\right)$	$\frac{\delta/\mu}{\mu M}$	40	60	80	120	180	240	320	400	500	600
0	0 0.0005 0.001	*	*	*	*	*	*	*	*	*	*
0.3	0 0.0005 0.001	-	-	-	-	-	-	-	-	-	-
0.5	0 0.0005 0.001	-	-	-	-	-	-	-	-	-	-
0.7	0 0.0005 0.001	5.687 6.174 6.623	7.362 8.195 8.946	8.721 9.953 11.038	10.944 13.091 14.905	13.614 17.347 20.341	15.840 21.343 25.562	18.394 26.457 32.333	20.634 31.425 38.953	23.131 37.502 47.059	25.384 43.472 55.000
0.8	0 0.0005 0.001	9.946 10.287 10.614	12.556 13.158 13.724	14.711 15.614 16.450	18.273 19.878 21.313	22.587 25.428 27.855	26.200 30.443 33.919	30.356 36.652 41.558	34.004 42.516 48.841	38.079 49.522 57.591	41.758 56.255 66.029
0.9	0 0.0005 0.001	14.846 15.080 15.307	18.581 18.997 19.391	21.682 22.308 22.893	26.830 27.946 28.957	33.081 35.067 36.786	38.326 41.295 43.776	44.367 48.795 52.314	49.678 55.676 60.280	55.607 63.680 69.775	60.971 71.247 79.007
1.0	0 0.0005 0.001	18.137 18.225 18.308	22.602 22.753 22.894	26.319 26.544 26.749	32.503 32.896 33.239	40.025 40.712 41.277	46.343 47.356 48.151	53.620 55.107 56.223	60.022 62.013 63.492	67.171 69.825 71.909	73.629 76.979 80.058
1.1	0 0.0005 0.001	17.357 17.319 17.279	21.573 21.498 21.418	25.091 24.970 24.841	30.949 30.717 30.464	38.083 37.639 37.134	44.077 43.372 42.534	50.984 49.860 48.433	57.061 55.451 53.211	63.850 61.484 57.824	69.982 66.739 60.807
1.3	0 0.0005 0.001	12.349 12.247 12.143	15.306 15.116 14.921	17.777 17.482 17.176	21.898 21.349 20.766	26.922 25.896 24.762	31.146 29.539 27.674	36.015 33.481 30.297	40.300 36.665 31.620	45.088 39.818 31.215	49.413 42.195 27.321
1.5	0 0.0005 0.001	9.171 9.071 8.969	11.349 11.165 10.974	13.172 12.886 12.586	16.214 15.682 15.108	19.925 18.927 17.801	23.046 21.479 19.610	26.644 24.162 20.929	29.811 26.234 21.031	33.349 28.134 18.999	36.547 29.358 12.240
$X_a = 0.1$		$X_0 = 0.4$				$r_a^2 = 0.25$					

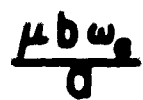
TABLE 21
WADC TN 57-310



FOR BENDING-TORSION FLUTTER

$\frac{b}{h}$ ($\frac{b}{h}$)	$\frac{b}{h}$ μM	40	60	80	120	180	240	320	400	500	600
0	0.0005 0.001	*	*	*	*	*	*	*	*	*	*
0.3	0.0005 0.001	*	*	*	*	*	*	*	*	*	*
0.5	0.0005 0.001	-	-	-	-	-	-	-	-	-	-
0.7	0.0005 0.001	4.260	5.632	6.730	8.511	10.637	12.404	14.428	16.200	18.174	19.954
0.8	0.0005 0.001										
0.9	0.0005 0.001										
1.0	0.0005 0.001										
1.1	0.0005 0.001										
1.3	0.0005 0.001										
1.5	0.0005 0.001										
$\alpha_a = 0.1$		$\alpha_0 = 0.4$						$r_a^2 = 0.36$			

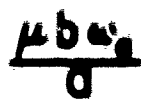
TABLE 22
WADC TN 57-310



FOR BENDING-TORSION FLUTTER

$(\frac{bh}{\omega a})$	$\frac{b}{h}$	40	60	80	120	180	240	320	400	500	600
0	0 0.0005 0.001	1.422 2.940	3.208 5.018	4.676 6.953	7.413 10.701	11.374 16.230	15.283 21.722	20.464 29.025	25.631 36.316	32.079 45.424	38.521 54.527
0.3	0 0.0005 0.001	4.369 5.119 5.773	5.673 6.942 8.012	6.729 8.587 10.107	8.453 11.638 14.116	10.523 15.956 19.944	12.247 20.137 25.679	14.226 25.614 33.253	15.960 31.028 40.779	17.894 37.747 50.140	19.638 44.429 59.459
0.5	0 0.0005 0.001	8.881 9.334 9.764	11.173 11.974 12.723	13.068 14.275 15.381	16.208 18.352 20.257	20.014 23.812 27.044	23.204 28.875 33.526	26.874 35.295 41.920	30.101 41.491 50.142	33.702 49.043 60.261	36.954 56.453 70.255
0.7	0 0.0005 0.001	14.395 25.742 15.080	17.976 18.601 19.203	20.953 21.904 22.809	25.901 27.616 29.213	31.916 34.997 37.788	36.965 41.619 45.738	42.779 49.785 55.830	47.893 57.484 65.613	53.603 66.696 77.669	58.762 75.610 89.782
0.8	0 0.0005 0.001	16.907 17.208 17.501	21.077 21.621 22.145	24.548 25.377 26.168	30.323 31.817 33.223	37.346 40.045 42.508	43.241 47.328 50.978	50.038 56.201 61.616	56.005 64.452 71.805	62.677 74.238 84.385	68.705 83.624 97.232
0.9	0 0.0005 0.001	18.367 18.590 18.806	22.871 23.273 23.658	26.624 27.245 27.812	32.866 33.974 34.977	40.462 42.440 44.167	46.848 49.814 52.299	54.201 58.641 62.161	60.679 66.696 71.175	67.884 76.028 81.649	74.412 84.757 91.209
1.0	0 0.0005 0.001	18.402 18.522 18.635	22.894 23.109 23.302	26.640 26.962 27.242	32.874 33.443 33.897	40.463 41.451 42.123	46.838 48.275 49.062	54.184 56.226 56.901	60.647 63.265 63.367	67.865 71.110 69.431	74.386 78.091 72.462
1.1	0 0.0005 0.001	17.367 17.393 17.412	21.594 21.635 21.656	25.119 25.175 25.188	30.989 31.069 31.028	38.136 38.223 37.967	44.140 44.185 43.500	51.059 50.943 49.223	57.147 56.721 53.210	63.946 62.871 55.434	70.089 68.003 53.236
1.3	0 0.0005 0.001	14.369 14.291 14.207	17.851 17.703 17.537	20.758 20.523 20.251	25.598 25.147 24.592	31.494 30.164 29.431	36.449 35.016 32.919	42.158 39.789 35.900	47.182 43.631 37.050	52.794 47.381 35.423	57.864 50.099 28.356
1.5	0 0.0005 0.001	11.813 11.704 11.590	14.668 14.464 14.246	17.052 16.733 16.385	21.023 20.422 19.736	25.862 24.715 23.319	29.927 28.100 25.712	34.614 31.664 27.405	38.737 34.414 27.411	43.343 36.916 24.459	47.504 38.490 15.234
$X_a = 0.1$		$X_0 = 0.45$			$r_a^2 = 0.09$						

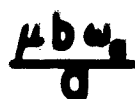
TABLE 23



FOR BENDING-TORSION FLUTTER

$\left(\frac{bh}{\omega a}\right)$	$\frac{b}{h}$	$\frac{\mu M}{\mu}$	40	60	80	120	180	240	320	400	500	600
0	0	0.0005 0.001	1.153 2.384	2.602 4.070	3.793 5.639	6.012 8.679	9.225 13.163	12.395 17.617	16.597 23.540	20.787 29.453	26.017 36.840	27.221 44.223
0.3	0	0.0005 0.001	2.710 3.474 4.097	3.625 4.873 5.861	4.351 6.147 7.524	5.524 8.539 10.733	6.920 11.967 15.428	8.078 15.315 20.066	9.403 19.723 26.204	10.563 24.095 32.309	11.855 29.532 39.907	13.019 34.947 47.473
0.5	0	0.0005 0.001	6.019 6.462 6.874	7.619 8.394 9.099	8.937 10.094 11.125	11.113 13.152 14.896	13.746 17.318 20.224	15.949 21.239 25.364	18.484 26.267 32.057	20.710 31.160 38.632	23.194 37.158 46.730	25.437 43.065 54.722
0.7	0	0.0005 0.001	11.003 11.320 11.626	13.765 14.332 14.872	16.060 16.917 17.722	19.869 21.406 22.808	24.496 27.239 29.650	28.379 32.499 36.001	32.849 39.008 44.040	36.781 45.156 51.770	41.170 52.512 61.151	45.135 59.614 70.324
0.8	0	0.0005 0.001	14.346 14.618 14.882	17.900 18.390 18.859	20.858 21.600 22.305	25.774 27.110 28.350	31.753 34.151 36.307	36.771 40.389 43.560	42.555 47.990 52.632	47.633 55.061 61.274	53.310 63.431 71.804	58.438 71.440 82.270
0.9	0	0.0005 0.001	17.440 17.644 17.841	21.723 22.088 22.440	25.291 25.846 26.374	31.226 32.228 33.161	38.450 40.252 41.878	44.516 47.233 49.641	51.503 55.590 59.152	57.658 63.246 68.136	64.523 72.169 78.958	70.746 80.582 89.946
1.0	0	0.0005 0.001	18.589 18.675 18.756	23.125 23.277 23.417	26.907 27.135 27.340	33.202 33.607 33.947	40.865 41.574 42.113	47.303 48.346 49.051	54.721 56.234 57.064	61.247 63.237 64.025	68.536 71.106 71.456	75.121 78.225 77.362
1.1	0	0.0005 0.001	17.346 17.317 17.284	21.558 21.501 21.431	25.073 24.979 24.862	30.926 30.740 30.485	38.053 37.677 37.098	44.042 43.410 42.332	50.943 49.860 47.753	57.015 55.340 51.607	63.797 61.153 54.035	69.925 66.010 52.698
1.3	0	0.0005 0.001	13.008 12.887 12.762	16.147 15.922 15.685	18.768 18.418 18.043	23.136 22.480 21.753	28.457 27.220 25.763	32.930 30.971 28.507	38.085 34.951 30.590	42.621 38.060 30.905	47.687 40.958 28.185	52.265 42.881 18.990
1.5	0	0.0005 0.001	9.921 9.792 9.659	12.306 12.066 11.816	14.298 13.926 13.532	17.619 16.926 16.165	21.666 20.363 18.848	25.068 23.011 20.462	28.990 25.710 21.217	32.441 27.683 20.294	36.296 29.298 15.702	39.780 30.045 -
$X_a = 0.1$			$X_0 = 0.45$			$r_a^2 = 0.16$						

TABLE 24



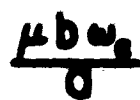
FOR BENDING-TORSION FLUTTER

$\frac{\omega h}{\omega_n}$	$\frac{\delta/\mu}{\mu M}$	40	60	80	120	180	240	320	400	500	600
0	0.0005 0.001	1.005 2.077	2.267 3.546	3.305 4.913	5.238 7.562	8.037 11.459	10.799 15.350	14.461 20.510	18.112 25.663	22.669 32.099	27.221 38.532
0.3	0.0005 0.001	1.919 2.698 3.298	2.656 3.892 4.819	3.229 4.980 6.257	4.143 7.035 9.039	5.223 9.996 13.122	6.115 12.900 17.161	7.133 16.731 22.510	8.022 20.537 27.833	9.012 25.273 34.458	9.903 29.992 41.057
0.5	0.0005 0.001	4.590 5.030 5.434	5.844 6.609 7.290	6.873 8.009 8.996	8.568 10.553 12.201	10.615 14.064 16.773	12.327 17.400 21.209	14.293 21.708 27.007	16.020 25.921 32.713	17.947 31.104 39.749	19.686 36.220 46.693
0.7	0.0005 0.001	8.932 9.236 9.528	11.195 11.735 12.244	13.072 13.886 14.640	16.185 17.637 18.940	19.965 22.543 24.760	23.135 26.992 30.180	26.785 32.522 37.047	29.993 37.761 43.639	33.576 44.042 51.603	36.811 50.109 59.329
0.8	0.0005 0.001	12.426 12.677 12.919	15.518 15.967 16.394	18.090 18.768 19.405	22.363 23.578 24.690	27.558 29.727 31.639	31.918 35.175 37.954	36.936 41.812 45.795	41.350 47.978 53.217	46.281 55.255 62.111	50.734 62.191 70.730
0.9	0.0005 0.001	16.576 16.754 16.929	20.652 20.973 21.281	24.048 24.534 24.995	29.696 30.571 31.385	36.568 38.136 39.559	42.340 44.703 46.817	48.994 52.544 55.676	54.832 59.719 64.018	61.383 68.041 74.043	67.267 75.897 84.095
1.0	0.0005 0.001	18.742 18.800 18.856	23.312 23.414 23.512	27.123 27.277 27.421	33.467 33.741 33.991	41.191 41.678 42.104	47.679 48.408 49.026	55.155 56.242 57.134	61.733 63.208 64.401	69.079 71.076 72.705	75.716 78.267 80.471
1.1	0.0005 0.001	16.976 16.920 16.862	21.090 20.985 20.875	24.523 24.360 24.184	30.242 29.935 29.591	37.207 36.625 35.929	43.060 42.136 40.945	49.806 48.320 46.179	55.741 53.568 50.002	62.370 59.143 52.700	68.360 63.828 52.196
1.3	0.0005 0.001	11.428 11.303 11.175	14.174 13.945 13.705	16.469 16.113 15.735	20.294 19.632 18.902	24.956 23.710 22.253	28.875 26.908 24.446	33.392 30.252 25.888	37.367 32.804 25.594	41.807 35.080 21.902	45.819 36.436 8.519
1.5	0.0005 0.001	8.260 8.136 8.008	10.235 10.007 9.766	11.887 11.532 11.153	14.641 13.980 13.247	17.998 16.755 15.284	20.821 18.854 16.355	24.076 20.929 16.439	26.940 22.354 14.737	30.140 23.352 7.534	33.031 23.513 -
$X_a = 0.1$		$X_0 = 0.45$				$r_a^2 = 0.25$					

TABLE 25 $\sqrt{\frac{b}{a}}$ FOR BENDING-TORSION FLUTTER
WADC TN 57-310

$(\frac{bh}{\omega a})$	$\frac{\delta/\mu}{\mu M}$	40	60	80	120	180	240	320	400	500	600
0	0 0.0005 0.001	*	*	*	*	*	*	*	*	*	*
0.3	0 0.0005 0.001	1.478	2.123	2.613	3.387	4.293	5.040	5.889	6.631	7.455	8.197
0.5	0 0.0005 0.001	3.785	4.846	5.713	7.138	8.855	10.290	11.938	13.384	14.997	16.453
0.7	0 0.0005 0.001	7.648	9.601	11.218	13.899	17.153	19.881	23.020	25.781	28.862	31.645
0.8	0 0.0005 0.001										
0.9	0 0.0005 0.001										
1.0	0 0.0005 0.001										
1.1	0 0.0005 0.001										
1.3	0 0.0005 0.001										
1.5	0 0.0005 0.001										
$X_a = 0.1$		$X_0 = 0.45$				$r_a^2 = 0.36$					

TABLE 26
WADC TN 57-310



FOR BENDING-TORSION FLUTTER

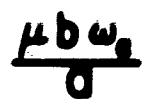
$\left(\frac{bh}{w^3}\right)$	$\frac{\delta/\mu}{\mu M}$	40	60	80	120	180	240	320	400	500	600
0	0 0.0005 0.001	7.088 7.532 7.952	8.824 9.605 10.336	10.249 11.446 12.525	12.643 14.711 16.618	15.557 19.315 22.424	18.007 23.596 28.041	20.829 29.091 35.381	23.312 34.444 42.619	26.085 41.016 51.573	28.591 47.500 60.454
0.3	0 0.0005 0.001	8.847 9.236 9.609	10.998 11.696 12.351	12.793 13.848 14.823	15.781 17.669 19.361	19.419 22.780 25.668	22.476 27.508 31.684	25.999 33.492 39.465	29.098 39.257 47.083	32.560 46.273 56.456	35.688 53.149 65.714
0.5	0 0.0005 0.001	12.161 12.497 12.823	15.118 15.723 16.303	17.585 18.505 19.375	21.693 23.349 24.880	26.694 29.667 32.329	30.897 35.380 39.284	35.739 42.471 48.145	40.000 49.194 56.727	44.759 57.270 67.215	49.058 65.102 77.536
0.7	0 0.0005 0.001	17.105 17.404 17.699	21.264 21.810 22.341	24.733 25.568 26.374	30.511 32.027 33.471	37.546 40.293 42.865	43.456 47.634 51.494	50.267 56.604 62.399	56.259 65.000 72.974	62.953 74.991 80.095	69.000 84.629 99.478
0.8	0 0.0005 0.001	19.255 19.514 19.769	23.937 24.412 24.874	27.842 28.569 29.273	34.348 35.673 36.936	42.265 44.676 46.920	48.923 52.588 55.972	56.596 62.161 67.237	63.330 70.992 78.020	70.864 81.424 91.302	77.672 91.389 104.880
0.9	0 0.0005 0.001	20.026 20.196 20.357	24.896 25.206 25.499	28.957 29.430 29.870	35.723 36.578 37.340	43.962 45.491 46.776	50.885 53.179 54.965	58.864 62.257 64.604	65.881 70.464 73.088	73.721 79.808 82.088	80.792 88.387 88.804
1.0	0 0.0005 0.001	19.149 19.199 19.240	23.805 23.895 23.962	27.689 27.823 27.910	34.157 34.384 34.480	42.032 42.393 42.378	48.648 49.113 48.763	56.273 56.792 55.480	62.982 63.418 60.258	70.475 70.547 63.021	77.245 76.568 60.397
1.1	0 0.0005 0.001	17.319 17.273 17.217	21.531 21.442 21.329	25.044 24.902 24.709	30.894 30.612 30.185	38.017 37.436 36.433	44.002 43.004 41.081	50.898 49.142 45.265	56.966 54.183 47.167	63.743 59.232 45.594	69.866 63.034 36.793
1.3	0 0.0005 0.001	13.513 13.378 13.235	16.799 16.548 16.276	19.539 19.149 18.714	24.104 23.367 22.504	29.661 28.253 26.468	34.330 32.073 28.971	39.711 36.037 30.381	44.445 39.012 29.490	49.733 41.564 23.873	54.510 42.919 -
1.5	0 0.0005 0.001	10.754 10.602 10.444	13.369 13.088 12.790	15.550 15.114 14.642	19.182 18.367 17.445	23.605 22.062 20.195	27.321 24.868 21.681	31.603 27.658 21.936	35.370 29.597 20.003	39.579 31.001 12.267	43.381 31.332 -
$X_a = 0.1$		$X_0 = 0.5$				$r_a^2 = 0.09$					

TABLE 27
WADC TN 57-310

μ_{dc} FOR BENDING-TORSION FLUTTER

$\left(\frac{\omega_h}{\omega_n}\right)$	$\frac{\delta/\mu}{\mu M}$	40	60	80	120	180	240	320	400	500	600
0	0 0.0005 0.001	5.738 6.096 6.433	7.134 7.772 8.358	8.298 9.259 10.124	10.236 11.945 13.423	12.596 15.611 18.093	14.579 19.060 22.601	16.864 23.480 28.476	18.874 27.781 34.255	21.120 33.052 41.386	23.148 38.244 48.438
0.3	0 0.0005 0.001	6.802 7.131 7.443	8.457 9.044 9.591	9.836 10.723 11.535	12.134 13.717 15.117	14.932 17.740 20.114	17.282 21.475 24.887	19.991 26.214 31.061	22.374 30.786 37.100	25.036 36.354 44.517	27.441 41.810 51.828
0.5	0 0.0005 0.001	9.031 9.325 9.604	11.232 11.752 12.245	13.065 13.852 14.589	16.116 17.530 18.814	19.832 22.356 24.564	22.954 26.745 29.951	26.552 32.216 36.819	29.717 37.417 43.462	33.253 43.675 51.552	36.447 49.746 59.473
0.7	0 0.0005 0.001	13.384 13.636 13.882	16.639 17.093 17.532	19.354 20.046 20.706	23.874 25.124 26.293	29.379 31.629 33.675	34.004 37.406 40.426	39.333 44.459 48.887	44.022 51.043 56.979	49.260 58.847 66.795	53.991 66.329 76.436
0.8	0 0.0005 0.001	16.437 16.665 16.889	20.434 20.849 21.252	23.768 24.402 25.013	29.321 30.469 31.563	36.080 38.163 40.109	41.761 44.928 47.845	48.314 53.104 57.505	54.061 60.671 66.735	60.494 69.598 78.093	66.304 78.129 89.590
0.9	0 0.0005 0.001	18.990 19.158 19.322	23.607 23.916 24.214	27.460 27.929 28.384	33.876 34.731 35.547	41.568 43.241 44.694	48.247 50.611 52.807	55.815 59.402 62.721	62.476 67.402 72.019	69.911 76.741 83.275	76.606 85.497 94.572
1.0	0 0.0005 0.001	19.149 19.193 19.233	23.805 23.886 23.955	27.689 27.811 27.909	34.157 34.372 34.519	42.032 42.399 42.567	48.648 49.166 49.252	56.273 56.968 56.685	62.982 63.800 62.683	70.475 71.333 68.048	77.245 77.960 70.106
1.1	0 0.0005 0.001	16.943 16.868 16.788	21.063 20.925 20.770	24.499 24.284 24.034	30.222 29.813 29.303	37.190 36.396 35.297	43.045 41.751 39.767	49.791 47.640 43.852	55.727 52.477 45.850	62.357 57.341 44.749	68.347 61.046 37.045
1.3	0 0.0005 0.001	11.865 11.704 11.537	14.750 14.453 14.140	17.156 16.697 16.201	21.164 20.307 19.340	26.043 24.424 22.468	30.143 27.573 24.225	34.867 30.736 24.693	39.024 32.976 22.765	43.667 34.671 14.576	47.861 35.200 -
1.5	0 0.0005 0.001	8.727 8.562 8.392	10.849 10.547 10.228	12.619 12.152 11.648	15.567 14.695 13.718	19.156 17.153 15.541	22.171 19.568 16.188	25.646 21.468 15.285	28.703 22.594 11.606	32.118 23.025 -	35.203 22.356 -
$X_a = 0.1$		$X_0 = 0.5$				$r_a^2 = 0.16$					

TABLE 28
WADC TN 57-310



FOR BENDING-TORSION FLUTTER

$\left(\frac{bh}{w^3}\right)$	$\frac{\delta/\mu}{\mu M}$	40	60	80	120	180	240	300	400	500	600
0	0 0.0005 0.001	4.992 5.301 5.592	6.206 6.757 7.263	7.218 8.049 8.794	8.904 10.380 11.651	10.957 13.558 15.688	12.682 16.544 19.577	14.670 20.367 26.234	16.419 24.081 29.595	18.372 28.625 35.700	20.137 33.094 41.721
0.3	0 0.0005 0.001	5.762 6.053 6.329	7.164 7.683 8.166	8.332 9.117 9.831	10.279 11.676 12.902	12.649 15.122 17.191	14.640 18.327 21.288	16.934 22.394 26.581	18.953 26.320 31.748	21.208 31.097 38.083	23.245 35.776 44.310
0.5	0 0.0005 0.001	7.455 7.717 7.969	9.267 9.737 10.180	10.779 11.490 12.149	13.297 14.570 15.712	16.363 18.628 20.578	18.939 22.331 25.144	21.907 26.959 30.968	24.519 31.365 36.594	27.436 36.671 43.434	30.071 41.820 50.112
0.7	0 0.0005 0.001	11.137 11.361 11.578	13.846 14.247 14.632	16.105 16.715 17.291	19.867 20.963 21.973	24.447 26.411 28.159	28.296 31.254 33.804	32.730 37.164 40.846	36.632 42.677 47.539	40.990 49.197 55.574	44.928 55.428 63.354
0.8	0 0.0005 0.001	14.300 14.497 14.689	17.777 18.133 18.476	20.678 21.219 21.736	25.507 26.485 27.402	31.388 33.150 34.757	36.331 38.996 41.380	42.025 46.037 49.556	47.032 52.537 57.281	52.627 60.158 66.582	57.683 67.392 75.685
0.9	0 0.0005 0.001	17.940 18.089 18.236	22.303 22.573 22.840	25.941 26.356 26.762	32.003 32.756 33.490	39.381 40.750 42.077	45.576 47.671 49.703	52.734 55.937 59.049	59.008 63.449 67.884	66.053 72.206 78.713	72.395 80.477 89.801
1.0	0 0.0005 0.001	19.149 19.187 19.224	23.805 23.876 23.943	27.689 27.798 27.899	34.157 34.355 34.530	42.032 42.388 42.674	48.646 49.181 49.561	56.273 57.058 57.499	62.982 64.025 64.391	70.475 71.834 71.745	77.245 78.888 77.541
1.1	0 0.0005 0.001	16.413 16.328 16.239	20.404 20.249 20.081	23.734 23.492 23.226	29.277 28.826 28.300	36.028 35.170 34.078	41.699 40.327 38.412	48.235 46.001 42.443	53.985 50.673 44.560	60.408 55.401 43.930	66.210 59.050 37.290
1.3	0 0.0005 0.001	10.257 10.093 9.922	12.752 12.450 12.130	14.832 14.366 13.861	18.297 17.427 16.444	22.516 20.874 18.881	26.060 23.454 20.026	30.144 25.952 19.676	33.738 27.592 16.639	37.752 28.581 -	41.378 28.401 -
1.5	0 0.0005 0.001	7.090 6.925 6.753	8.814 8.511 8.190	10.252 9.784 9.277	12.647 11.775 10.783	15.562 13.915 11.883	18.012 15.392 11.829	20.835 16.604 9.682	23.319 17.082 -	26.093 16.676 -	28.600 14.984 -
$X_a = 0.1$		$X_0 = 0.5$				$r_a^2 = 0.25$					

TABLE 29

 $\frac{\mu b^2}{\rho^2}$

FOR BENDING-TORSION FLUTTER

$\frac{\omega_h}{(\omega_a)}$	$\frac{\delta/\mu}{\mu M}$	40	60	80	120	180	240	320	400	500	600
0	0 0.0005 0.001	4.535	5.638	6.558	8.090	9.955	11.522	13.328	14.917	16.691	18.295
0.3	0 0.0005 0.001	5.156	6.410	7.456	9.197	11.318	13.099	15 152	16.959	18.976	20.799
0.5	0 0.0005 0.001	6.551	8.143	9.472	11.685	14.379	16.642	19.251	21.546	24.109	26.425
0.7	0 0.0005 0.001	9.757	12.130	14.109	17.404	21.417	24.789	28.674	32.092	35.910	39.359
0.8	0 0.0005 0.001										
0.9	0 0.0005 0.001										
1.0	0 0.0005 0.001										
1.1	0 0.0005 0.001										
1.3	0 0.0005 0.001										
1.5	0 0.0005 0.001										
$X_a = 0.1$		$X_0 = 0.5$				$r_a^2 = 0.36$					

TABLE 30 $\frac{\mu b e}{\rho$ FOR BENDING-TORSION FLUTTER
WADC TN 57-310

$\left(\frac{b}{a}\right)$	$\frac{\mu M}{8/\mu}$	40	60	80	120	180	240	320	400	500	600
0	0 0.0005 0.001	10.171	12.546	14.539	17.869	21.937	25.360	29.309	32.785	36.670	40.182
0.3	0 0.0005 0.001										
0.5	0 0.0005 0.001										
0.7	0 0.0005 0.001										
0.8	0 0.0005 0.001										
0.9	0 0.0005 0.001										
1.0	0 0.0005 0.001										
1.1	0 0.0005 0.001										
1.3	0 0.0005 0.001										
1.5	0 0.0005 0.001										
$\chi_a = 0.1$		$\chi_0 = 0.55$				$r_a^2 = 0.09$					

TABLE 31 $\frac{\mu b \omega}{8}$ FOR BENDING-TORSION FLUTTER
WADC TN 57-310

$\left(\frac{bh}{a^3}\right)$	$\frac{\delta/\mu}{\mu M}$	40	60	80	120	180	240	320	400	500	600
0	0 0.0005 0.001	8.196	10.110	11.716	14.400	17.677	20.436	23.618	26.419	29.550	32.379
0.3	0 0.0005 0.001										
0.5	0 0.0005 0.001										
0.7	0 0.0005 0.001										
0.8	0 0.0005 0.001										
0.9	0 0.0005 0.001										
1.0	0 0.0005 0.001										
1.1	0 0.0005 0.001										
1.3	0 0.0005 0.001										
1.5	0 0.0005 0.001										
$x_a = 0.1$		$x_0 = 0.55$				$r_a^2 = 0.16$					

TABLE 32 $\frac{\mu b a}{\sigma}$ FOR BENDING-TORSION FLUTTER
WADC TN 57-310

$\left(\frac{b}{h}\right)$	$\frac{8/\mu}{\mu M}$	40	60	80	120	180	240	320	400	500	600
0	0 0.0005 0.001	7.098	8.756	10.147	12.471	15.310	17.699	20.454	22.881	25.592	28.042
0.3	0 0.0005 0.001										
0.5	0 0.0005 0.001										
0.7	0 0.0005 0.001										
0.8	0 0.0005 0.001										
0.9	0 0.0005 0.001										
1.0	0 0.0005 0.001										
1.1	0 0.0005 0.001										
1.3	0 0.0005 0.001										
1.5	0 0.0005 0.001										
$X_a = 0.1$		$X_0 = 0.55$				$r_a^2 = 0.25$					

TABLE 33 $\frac{\mu b c_a}{\rho}$ FOR BENDING-TORSION FLUTTER
WADC TN 57-310

$\left(\frac{\omega_h}{\omega_a}\right)$	$\frac{\delta/\mu}{\mu M}$	40	60	80	120	180	240	320	400	500	600
0	0 0.0005 0.001	6.424	7.924	9.182	11.286	13.855	16.017	18.511	20.707	23.160	25.378
0.3	0 0.0005 0.001										
0.5	0 0.0005 0.001										
0.7	0 0.0005 0.001										
0.8	0 0.0005 0.001										
0.9	0 0.0005 0.001										
1.0	0 0.0005 0.001										
1.1	0 0.0005 0.001										
1.3	0 0.0005 0.001										
1.5	0 0.0005 0.001										
$x_a = 0.1$		$x_0 = 0.55$					$r_a^2 = 0.36$				

TABLE 34 $\frac{\mu b \omega_a}{\sigma}$ FOR BENDING-TORSION FLUTTER
WADC TN 57-310

$\frac{\omega_h}{(\omega_a)}$	$\frac{\delta/\mu}{\mu M}$	40	60	80	120	180	240	320	400	500	600
0	0 0.0005 0.001	*	*	*	*	*	*	*	*	*	*
0.3	0 0.0005 0.001	*	*	*	*	*	*	*	*	*	*
0.5	0 0.0005 0.001	6.316 6.784 7.222	7.986 8.808 9.559	9.362 10.592 11.692	11.637 13.806 15.674	14.389 18.197 21.325	16.694 22.342 26.802	19.344 27.672 33.973	21.673 32.875 41.058	24.271 39.276 49.845	26.617 45.603 58.583
0.7	0 0.0005 0.001	9.522 9.827 10.123	11.848 12.397 12.921	13.788 14.620 15.405	17.016 18.513 19.890	20.945 23.627 26.015	24.246 28.285 31.179	28.049 34.107 39.199	31.394 39.662 46.449	35.131 46.374 55.438	38.507 52.923 64.513
0.8	0 0.0005 0.001										
0.9	0 0.0005 0.001										
1.0	0 0.0005 0.001										
1.1	0 0.0005 0.001										
1.3	0 0.0005 0.001										
1.5	0 0.0005 0.001										
$X_a = 0.2$		$X_0 = 0.35$		$r_a^2 = 0.09$							

TABLE 35 $\frac{\mu b a}{\rho L^3}$ FOR BENDING-TORSION FLUTTER
WADC TN 57-310

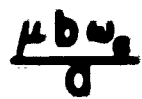
$(\frac{b}{a})$	$\frac{8/\mu}{\mu M}$	40	60	80	120	180	240	320	400	500	600
0	0 0.0005 0.001	*	*	*	*	*	*	*	*	*	*
0.3	0 0.0005 0.001	*	*	*	*	*	*	*	*	*	*
0.5	0 0.0005 0.001	3.818 4.373 4.864	4.958 5.899 8.639	5.880 7.262 8.416	7.388 9.767 11.662	9.197 13.276 16.346	10.705 16.653 20.934	12.434 21.055 26.972	13.950 25.393 32.950	15.64C 30.760 40.360	17.164 36.086 47.707
0.7	0 0.0005 0.001	8.333 8.621 8.898	10.388 10.903 11.391	12.099 12.879 13.605	14.945 16.340 17.602	18.406 20.893 23.052	21.312 25.041 28.165	24.660 30.222 34.688	27.604 35.154 40.997	30.893 41.092 48.690	33.864 46.857 56.249
0.8	0 0.0005 0.001										
0.9	0 0.0005 0.001										
1.0	0 0.0005 0.001										
1.1	0 0.0005 0.001										
1.3	0 0.0005 0.001										
1.5	0 0.0005 0.001										
		$X_a = 0.2$			$X_0 = 0.35$			$r_a^2 = 0.16$			

TABLE 36
WADC TN 57-310

$\frac{\mu b}{\rho a}$ FOR BENDING-TORSION FLUTTER
47

$\frac{bh}{(w_a)}$	$\frac{b}{h}$	$\frac{\mu M}{\mu}$	40	60	80	120	180	240	320	400	500	600
0	0	0.0005 0.001	*	*	*	*	*	*	*	*	*	*
0.3	0	0.0005 0.001	*	*	*	*	*	*	*	*	*	*
0.5	0	0.0005 0.001	2.033 2.798 3.394	2.877 4.073 4.988	3.524 5.214 6.475	4.550 7.342 9.326	5.756 10.380 13.487	6.750 13.343 17.589	7.883 17.242 23.013	8.872 21.107 28.401	9.971 25.912 35.096	10.961 30.693 41.750
0.7	0	0.0005 0.001	7.403 7.683 7.950	9.246 9.744 10.212	10.779 11.530 12.223	13.325 14.666 15.860	16.420 18.799 20.823	19.019 22.572 25.473	22.010 27.288 31.386	24.642 31.776 37.074	27.580 37.173 43.946	30.234 42.400 50.608
0.8	0	0.0005 0.001										
0.9	0	0.0005 0.001										
1.0	0	0.0005 0.001										
1.1	0	0.0005 0.001										
1.3	0	0.0005 0.001										
1.5	0	0.0005 0.001										
$X_a = 0.2$			$X_0 = 0.35$			$r_a^2 = 0.25$						

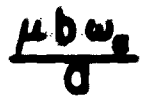
TABLE 37
WADC TN 57-310



FOR BENDING-TORSION FLUTTER

$\frac{\omega_h}{(\omega_a)}$	$\frac{\delta/\mu}{\mu M}$	40	60	80	120	180	240	320	400	500	600
0	0 0.0005 0.001	*	*	*	*	*	*	*	*	*	*
0.3	0 0.0005 0.001	*	*	*	*	*	*	*	*	*	*
0.5	0 0.0005 0.001	-	0.876	1.472	2.229	3.028	3.656	4.355	4.956	5.618	6.210
0.7	0 0.0005 0.001	6.708	8.394	9.793	12.117	14.939	17.307	20.034	22.431	25.109	27.527
0.8	0 0.0005 0.001										
0.9	0 0.0005 0.001										
1.0	0 0.0005 0.001										
1.1	0 0.0005 0.001										
1.3	0 0.0005 0.001										
1.5	0 0.0005 0.001										
$X_a = 0.2$		$X_0 = 0.35$				$r_a^2 = 0.36$					

TABLE 38
WADC TN 57-310



FOR BENDING-TORSION FLUTTER

$(\frac{b}{a})$	$\frac{\delta/\mu}{\mu M}$	40	60	80	120	180	240	320	400	500	600
0	0 0.0005 0.001	1.370 2.831	3.089 4.833	4.503 6.696	7.138 10.306	10.953 15.630	14.718 20.919	19.708 27.951	24.683 34.974	30.893 43.744	37.097 52.511
0.3	0 0.0005 0.001	5.780 6.297 6.774	7.283 8.191 9.006	8.526 9.881 11.070	10.581 12.964 14.967	13.072 17.234 20.554	15.159 21.302 26.005	17.559 26.572 33.167	19.669 31.742 40.260	22.024 38.122 49.063	24.151 44.444 57.815
0.5	0 0.0005 0.001	9.625 9.957 10.279	11.957 12.555 13.125	13.904 14.811 15.664	17.146 18.778 20.273	21.094 24.017 26.605	24.413 28.811 32.596	28.237 34.828 40.313	31.601 40.586 47.862	35.360 47.564 57.177	38.755 54.383 66.439
0.7	0 0.0005 0.001	11.894 12.154 12.409	14.723 15.195 15.652	17.090 17.810 18.500	21.039 22.343 23.571	25.856 28.210 30.374	29.906 33.474 36.693	34.577 39.966 44.742	38.688 46.091 52.912	43.280 53.429 62.370	47.305 60.544 72.401
0.8	0 0.0005 0.001										
0.9	0 0.0005 0.001										
1.0	0 0.0005 0.001										
1.1	0 0.0005 0.001										
1.3	0 0.0005 0.001										
1.5	0 0.0005 0.001										
$X_a = 0.2$		$X_0 = 0.4$		$r_a^2 = 0.09$							

TABLE 39 $\frac{\mu b}{a^2}$ FOR BENDING-TORSION FLUTTER
WADC TN 57-310

$(\frac{b}{a})$	$\frac{\delta/\mu}{\mu M}$	40	60	80	120	180	240	320	400	500	600
0	0 0.0005 0.001	1.117 2.309	2.520 3.942	3.673 5.461	5.822 8.405	8.934 12.748	12.004 17.062	16.074 22.797	20.132 28.525	25.196 35.678	30.256 42.828
0.3	0 0.0005 0.001	3.889 4.404 4.864	4.955 5.844 6.613	5.828 7.144 8.248	7.268 9.548 11.371	9.006 12.931 15.895	10.459 16.194 20.333	12.128 20.452 26.182	13.594 24.652 31.980	15.229 29.852 39.177	16.705 35.014 46.327
0.5	0 0.0005 0.001	7.273 7.583 7.880	9.058 9.613 10.134	10.546 11.384 12.158	13.021 14.519 15.858	16.032 18.597 20.977	18.561 22.546 25.835	21.475 27.403 32.091	24.038 32.068 38.186	26.900 37.727 45.650	29.486 43.255 52.985
0.7	0 0.0005 0.001	10.499 10.728 10.951	13.005 13.419 13.815	15.101 15.730 16.326	18.597 19.731 20.782	22.860 24.897 26.727	26.444 29.518 32.207	30.577 35.197 39.120	34.213 40.528 45.770	38.277 46.878 53.894	41.948 52.992 61.963
0.8	0 0.0005 0.001										
0.9	0 0.0005 0.001										
1.0	0 0.0005 0.001										
1.1	0 0.0005 0.001										
1.3	0 0.0005 0.001										
1.5	0 0.0005 0.001										
$X_a = 0.2$		$X_0 = 0.4$				$r_a^2 = 0.16$					

TABLE 40 $\frac{\mu b}{a}$ FOR BENDING-TORSION FLUTTER
WADC TN 57-310

$\left(\frac{\omega_h}{\omega_a}\right)$	$\frac{\delta/\mu}{\mu M}$	40	60	80	120	180	240	320	400	500	600
0	0 0.0005 0.001	* 0.978 2.022	* 2.207 3.452	* 3.217 4.783	* 5.099 7.362	* 7.824 11.165	* 10.513 14.943	* 14.078 19.966	* 17.632 24.982	* 22.067 31.248	* 26.499 37.510
0.3	0 0.0005 0.001	2.955 3.472 3.921	3.807 4.687 5.424	4.500 5.790 6.837	5.636 7.848 9.552	7.003 10.772 13.506	8.143 13.610 17.395	9.452 17.328 22.527	10.601 21.004 27.618	11.881 25.562 33.937	13.037 30.091 40.212
0.5	0 0.0005 0.001	5.917 6.218 6.504	7.387 7.924 8.422	8.610 9.419 10.155	10.642 12.081 13.342	13.113 15.656 17.782	15.187 18.975 22.013	17.575 23.183 27.469	19.676 27.238 32.783	22.022 32.168 39.279	24.141 36.989 45.642
0.7	0 0.0005 0.001	9.443 9.651 9.851	11.705 12.078 12.434	13.595 14.162 14.694	16.747 17.766 18.697	20.590 22.413 24.016	23.821 26.562 28.892	27.545 31.645 34.993	30.823 36.401 40.800	34.485 42.039 47.788	37.793 47.438 54.578
0.8	0 0.0005 0.001										
0.9	0 0.0005 0.001										
1.0	0 0.0005 0.001										
1.1	0 0.0005 0.001										
1.3	0 0.0005 0.001										
1.5	0 0.0005 0.001										
$\chi_a = 0.2$		$\chi_0 = 0.4$				$r_a^2 = 0.25$					

TABLE 41 $\frac{\mu b c}{\rho$ FOR BENDING-TORSION FLUTTER
WADC TN 57-310

$\frac{bh}{(S^2)}$	$\frac{8/\mu}{\mu M}$	40	60	80	120	180	240	320	400	500	600
0	0 0.0005 0.001	*	*	*	*	*	*	*	*	*	*
0.3	0 0.0005 0.001	2.431	3.163	3.756	4.722	5.881	6.847	7.955	8.925	10.008	10.984
0.5	0 0.0005 0.001	5.093	6.373	7.435	9.199	11.341	13.139	15.208	17.028	19.061	20.896
0.7	0 0.0005 0.001	8.679	10.763	12.504	15.408	18.947	21.921	25.350	28.367	31.738	34.784
0.8	0 0.0005 0.001										
0.9	0 0.0005 0.001										
1.0	0 0.0005 0.001										
1.1	0 0.0005 0.001										
1.3	0 0.0005 0.001										
1.5	0 0.0005 0.001										
$X_a = 0.2$		$X_0 = 0.4$				$r_a^2 = 0.36$					

TABLE 42 $\frac{\mu b e}{\rho$ FOR BENDING-TORSION FLUTTER
WADC TN 57-310

$\left(\frac{b}{a}\right)$	$\frac{\delta/\mu}{\mu M}$	40	60	80	120	180	240	320	400	500	600
0	0 0.0005 0.001	6.832 7.262 7.668	8.493 9.261 9.969	9.879 11.037 12.083	12.186 14.247 16.038	14.996 18.636 21.655	17.357 22.773 27.095	20.077 28.087 34.212	22.471 33.269 41.240	25.144 39.636 49.947	27.559 45.923 58.595
0.3	0 0.0005 0.001	9.263 9.598 9.921	11.475 12.078 12.650	13.324 14.240 15.096	16.409 18.055 19.554	20.170 23.114 25.700	23.333 27.759 31.528	26.979 33.602 39.040	30.188 39.203 46.379	33.773 45.996 55.404	37.013 52.635 64.320
0.5	0 0.0005 0.001	12.177 12.454 12.725	15.053 15.557 16.044	17.462 18.231 18.968	21.484 22.877 24.189	26.392 28.907 31.219	30.520 34.334 37.767	35.281 41.042 46.114	39.472 47.384 54.229	44.155 54.992 64.228	48.387 62.373 74.205
0.7	0 0.0005 0.001	13.967 14.201 14.431	17.248 17.675 18.092	19.998 20.652 21.286	24.592 25.782 26.922	30.199 32.360 34.399	34.918 38.209 41.283	40.360 45.363 50.004	45.181 52.063 58.495	50.505 60.046 69.115	55.343 67.758 80.141
0.8	0 0.0005 0.001										
0.9	0 0.0005 0.001										
1.0	0 0.0005 0.001										
1.1	0 0.0005 0.001										
1.3	0 0.0005 0.001										
1.5	0 0.0005 0.001										
$X_a = 0.2$		$X_0 = 0.45$					$r_a^2 = 0.09$				

TABLE 43 $\frac{\mu b a}{\rho}$ FOR BENDING-TORSION FLUTTER
WADC TN 57-310

$\left(\frac{\rho h}{\omega a}\right)$	$\frac{\delta/\mu}{\mu M}$	40	60	80	120	180	240	320	400	500	600
0	0 0.0005 0.001	5.561 5.909 6.236	6.913 7.534 8.104	8.041 8.973 9.818	9.920 11.582 13.021	12.207 15.139 17.558	14.129 18.488 21.942	16.343 22.783 27.661	18.291 26.963 33.293	20.467 32.091 40.248	22.433 37.144 47.136
0.3	0 0.0005 0.001	7.102 7.390 7.666	8.804 9.321 9.808	10.227 11.010 11.735	12.599 14.002 15.260	15.491 17.990 20.141	17.922 21.665 24.775	20.724 26.301 30.747	23.190 30.753 36.718	25.945 36.155 43.159	28.434 41.434 50.750
0.5	0 0.0005 0.001	9.544 9.778 10.006	11.806 12.229 12.634	13.699 14.342 14.951	16.859 18.020 19.093	20.714 22.799 24.664	23.957 27.102 29.835	27.696 32.418 36.387	30.987 37.436 42.698	34.664 43.437 50.374	37.987 49.233 57.895
0.7	0 0.0005 0.001	12.272 12.466 12.657	15.158 15.512 15.856	17.578 18.118 18.639	21.619 22.600 23.530	26.551 28.326 29.977	30.701 33.396 35.867	35.487 39.570 43.263	39.701 45.323 50.383	44.409 52.140 59.140	48.663 58.684 67.966
0.8	0 0.0005 0.001										
0.9	0 0.0005 0.001										
1.0	0 0.0005 0.001										
1.1	0 0.0005 0.001										
1.3	0 0.0005 0.001										
1.5	0 0.0005 0.001										
$x_a = 0.2$		$x_0 = 0.45$					$r_a^2 = 0.16$				

TABLE 44 $\sqrt{\frac{\mu b e}{\rho a}}$ FOR BENDING-TORSION FLUTTER
WADC TN 57-310

$\frac{b}{h}$ ($\frac{b}{a}$)	$\frac{8/\mu}{\mu M}$	40	60	80	120	180	240	320	400	500	600
0	0 0.0005 0.001	4.862 5.164 5.447	6.044 6.582 7.076	7.030 7.841 8.569	8.672 10.113 11.355	10.672 13.211 15.294	12.352 16.124 19.091	14.288 19.853 24.032	15.991 23.478 28.883	17.894 27.916 34.858	19.612 32.282 40.755
0.3	0 0.0005 0.001	5.999 6.258 6.506	7.441 7.905 8.339	8.645 9.347 9.992	10.652 11.908 13.023	13.098 15.329 17.223	15.155 18.489 21.212	17.526 22.478 26.346	19.612 26.311 31.344	21.942 30.959 37.459	24.048 35.498 43.461
0.5	0 0.0005 0.001	8.047 8.257 8.461	9.958 10.337 10.698	11.557 12.133 12.673	14.226 15.261 16.206	17.482 19.334 20.961	20.220 23.005 25.369	23.377 27.542 30.939	26.155 31.822 36.283	29.260 36.936 42.746	32.065 41.864 49.033
0.7	0 0.0005 0.001	11.003 11.169 11.330	13.595 13.894 14.183	15.767 16.223 16.658	19.394 20.218 20.989	23.820 25.304 26.658	27.544 29.791 31.791	31.839 35.226 38.168	35.620 40.262 44.220	39.844 46.189 51.520	43.662 51.834 58.668
0.8	0 0.0005 0.001										
0.9	0 0.0005 0.001										
1.0	0 0.0005 0.001										
1.1	0 0.0005 0.001										
1.3	0 0.0005 0.001										
1.5	0 0.0005 0.001										
$X_0 = 0.2$		$X_0 = 0.45$						$r_a^2 = 0.25$			

TABLE 45 $\frac{b}{h}$ FOR BENDING-TORSION FLUTTER
WADC TN 57-310

$\frac{\omega_h}{(\omega_a)}$	$\frac{\delta/\mu}{\mu M}$	40	60	80	120	180	240	320	400	500	600
0	0 0.0005 0.001	4.436	5.515	6.414	7.913	9.737	11.270	13.036	14.590	16.326	17.895
0.3	0 0.0005 0.001	5.361	6.650	7.728	9.523	11.712	13.551	15.671	17.537	19.621	21.504
0.5	0 0.0005 0.001	7.260	8.842	10.264	12.636	15.529	17.963	20.768	23.237	25.996	28.488
0.7	0 0.0005 0.001	10.101	12.483	14.478	17.810	21.876	25.297	29.242	32.715	36.596	40.103
0.8	0 0.0005 0.001										
0.9	0 0.0005 0.001										
1.0	0 0.0005 0.001										
1.1	0 0.0005 0.001										
1.3	0 0.0005 0.001										
1.5	0 0.0005 0.001										
$X_a = 0.2$		$X_0 = 0.45$				$r_a^2 = 0.36$					

TABLE 46
WADC TN 57-310

$\frac{\mu b a}{\rho l}$ FOR BENDING-TORSION FLUTTER

$\left(\frac{b}{a}\right)$	$\frac{b}{\mu}$	$\frac{\mu M}{\mu}$	40	60	80	120	180	240	320	400	500	600
0	0	0	9.828 10.124 10.410	12.124 12.659 13.170	14.049 14.864 15.633	17.268 18.737 20.091	21.198 23.837 26.191	24.506 28.485 31.936	28.322 34.296 39.306	31.682 39.838 46.481	35.436 46.529 55.284	38.829 53.048 63.966
0.3	0	0	11.769 12.035 12.294	14.518 15.000 15.466	16.824 17.559 18.263	20.678 22.010 23.259	25.384 27.788 29.982	29.346 32.986 36.230	33.915 39.406 44.165	37.938 45.467 51.831	42.433 52.724 61.188	46.497 59.744 70.386
0.5	0	0	14.380 14.629 14.875	17.739 18.194 18.638	20.556 21.253 21.929	25.265 26.534 27.751	31.016 33.320 35.496	35.856 39.366 42.640	41.439 46.775 51.690	46.355 53.726 60.463	51.848 62.015 71.281	56.812 70.020 82.130
0.7	0	0	15.858 16.076 16.291	19.563 19.962 20.354	22.670 23.283 23.883	27.863 28.984 30.071	34.205 36.249 38.211	39.542 42.667 45.649	45.699 50.469 55.014	51.120 57.735 64.089	57.178 66.349 75.398	62.653 74.636 87.123
0.8	0	0										
0.9	0	0										
1.0	0	0										
1.1	0	0										
1.3	0	0										
1.5	0	0										
$X_a = 0.2$			$X_0 = 0.5$			$r_a^2 = 0.09$						

TABLE 47 $\frac{b}{a}$ FOR BENDING-TORSION FLUTTER
WADC TN 57-310

$\left(\frac{\sigma_h}{\sigma_a}\right)$	$\frac{\delta/\mu}{\mu M}$	40	60	80	120	180	240	320	400	500	600
0	0 0.0005 0.001	7.957 8.190 8.415	9.816 10.237 10.638	11.375 12.015 12.618	13.981 15.135 16.192	17.163 19.232 21.065	19.841 22.958 25.636	22.931 27.602 31.475	25.651 32.020 37.136	28.690 37.338 44.053	31.438 42.504 50.848
0.3	0 0.0005 0.001	9.189 9.402 9.610	11.336 11.722 12.092	13.136 13.724 14.282	16.145 17.208 18.194	19.820 21.731 23.451	22.913 25.800 28.327	26.481 30.822 34.500	29.622 35.557 40.444	33.132 41.217 47.667	36.304 46.680 54.734
0.5	0 0.0005 0.001	11.331 11.524 11.713	13.978 14.328 14.669	16.197 16.733 17.249	19.908 20.880 21.798	24.439 26.197 27.818	28.253 30.919 33.328	32.652 36.683 40.238	36.526 42.064 46.851	40.854 48.443 54.866	44.766 54.561 62.714
0.7	0 0.0005 0.001	13.822 13.999 14.173	17.050 17.374 17.692	19.758 20.254 20.740	24.285 25.190 26.069	29.812 31.462 33.051	34.464 36.986 39.404	39.831 43.681 47.377	44.555 49.898 55.077	49.835 57.250 64.621	54.607 64.304 74.384
0.8	0 0.0005 0.001										
0.9	0 0.0005 0.001										
1.0	0 0.0005 0.001										
1.1	0 0.0005 0.001										
1.3	0 0.0005 0.001										
1.5	0 0.0005 0.001										
$X_a = 0.2$		$X_0 = 0.5$					$r_a^2 = 0.16$				

TABLE 48

 $\frac{\mu b c}{\rho L^2}$

FOR BENDING-TORSION FLUTTER

$\frac{b}{a}$ ($\frac{b}{a}$)	$\frac{\delta/\mu}{\mu M}$	40	60	80	120	180	240	320	400	500	600
0	0 0.0005 0.001	6.922 7.119 7.310	8.539 8.895 9.234	9.895 10.437 10.945	12.162 13.137 14.026	14.930 16.676 18.211	17.260 19.887 22.120	19.948 23.878 27.094	23.176 27.664 31.897	24.958 32.208 37.740	27.348 36.610 43.456
0.3	0 0.0005 0.001	7.837 8.020 8.197	9.668 9.998 10.314	11.203 11.706 12.180	13.769 14.676 15.510	16.904 18.530 19.977	19.541 21.993 24.109	22.584 26.262 29.323	25.263 30.280 34.325	28.257 35.073 40.379	30.963 39.688 46.279
0.5	0 0.0005 0.001	9.604 9.765 9.924	11.847 12.141 12.424	13.728 14.176 14.603	16.873 17.683 18.439	20.714 22.172 23.495	23.946 26.152 28.102	27.675 30.997 33.847	30.958 35.507 39.306	34.627 40.833 45.869	37.942 45.920 52.236
0.7	0 0.0005 0.001	12.283 12.424 12.564	15.152 15.410 15.662	17.558 17.953 18.336	21.581 22.298 22.988	26.493 27.795 29.029	30.627 32.612 34.471	35.396 38.414 41.214	39.594 43.765 47.623	44.286 50.045 55.391	48.527 56.016 63.068
0.8	0 0.0005 0.001										
0.9	0 0.0005 0.001										
1.0	0 0.0005 0.001										
1.1	0 0.0005 0.001										
1.3	0 0.0005 0.001										
1.5	0 0.0005 0.001										
$\chi_a = 0.2$		$\chi_0 = 0.50$						$r_a^2 = 0.25$			

TABLE 49 $\frac{F_{be}}{q_a}$ FOR BENDING-TORSION FLUTTER
WADC TN 57-310

$\left(\frac{b}{a}\right)$	$\frac{\delta/\mu}{\mu M}$	40	60	80	120	180	240	320	400	500	600
0	0 0.0005 0.001	6.289	7.758	8.990	11.049	13.564	15.681	18.123	20.273	22.675	24.846
0.3	0 0.0005 0.001	7.037	8.681	10.060	12.365	15.179	17.548	20.280	22.686	25.374	27.804
0.5	0 0.0005 0.001	8.560	10.559	12.236	15.040	18.463	21.344	24.667	27.593	30.863	33.818
0.7	0 0.0005 0.001	11.196	13.812	16.005	19.671	24.149	27.917	32.264	36.092	40.369	44.234
0.8	0 0.0005 0.001										
0.9	0 0.0005 0.001										
1.0	0 0.0005 0.001										
1.1	0 0.0005 0.001										
1.3	0 0.0005 0.001										
1.5	0 0.0005 0.001										
$\chi_a = 0.2$		$\chi_0 = 0.50$				$r_a^2 = 0.36$					

TABLE 50
WADC TN 57-310



FOR BENDING-TORSION FLUTTER

ω_β/ω_h	δ/μ μM	40	80	120	240	400
0	0	-	-	48.113 46.406	70.061 63.702	91.123 81.612
	0.001	-	-	-	58.861 55.899	65.451 62.534
0.3	0	-	-	-	73.290 66.918	95.421 85.645
	0.001	-	-	-	61.500 58.792	68.482 65.677
0.4	0	-	-	-	76.128 69.793	99.217 89.232
	0.001	-	-	-	63.784 61.411	71.144 68.488
0.5	0	-	-	-	80.295 74.111	104.831 94.588
	0.001	-	-	-	66.991 65.488	75.037 72.727
0.6	0	-	-	-	86.391 80.720	113.176 102.672
	0.001	-	-	-	-	80.563 79.381
0.7	0	-	-	-	95.354 91.774	126.136 115.605
	0.001	-	-	-	-	-
0.8	0	-	-	-	-	148.183 139.407
	0.001	-	-	-	-	-
$x_1 = 0.8$		$x_\beta = 0.0$		$r_\beta^2 = 0.00196$		

TABLE 51 $\frac{\mu b \omega_h}{\sigma}$ FOR BENDING-AILERON FLUTTER

No real solutions for values of $\frac{\omega_\beta}{\omega_h}$ above 0.8 for the range of μM considered.

No Real Solutions

$$x_1 = 0.8$$

$$x_2 = 0.01$$

$$\zeta^2 = 0.001,96$$

TABLE 52 $\frac{\mu b \omega_n}{\sigma}$ FOR BENDING-AILERON FLUTTER

No Real Solutions

$x_1 = 0.8$	$x_\beta = 0.014$	$r_\beta^2 = 0.001,96$
-------------	-------------------	------------------------

TABLE 53 $\frac{\mu b \omega_h}{\sigma}$ FOR BENDING-AILERON FLUTTER

ω_β/ω_h	δ/μ ^{μM}	40	80	120	240	400
0	0	-	31.061 29.342	38.738 35.271	55.484 49.222	71.943 63.254
	0.001	-	29.287 28.470	35.730 33.320	46.716 43.101	51.752 48.396
0.3	0	-	32.275 31.031	40.482 37.089	58.094 51.660	75.367 66.352
	0.001	-	-	37.305 35.070	48.895 45.252	54.196 50.784
0.4	0	-	-	42.004 38.724	60.398 53.830	78.395 69.105
	0.001	-	-	38.664 36.657	50.816 47.170	56.355 52.909
0.5	0	-	-	44.214 41.203	63.804 57.071	82.885 73.205
	0.001	-	-	40.571 39.125	53.646 50.043	59.547 56.081
0.6	0	-	-	47.339 45.098	68.862 61.969	89.581 79.375
	0.001	-	-	-	57.822 54.409	64.287 60.875
0.7	0	-	-	-	76.701 69.816	100.060 89.176
	0.001	-	-	-	64.151 61.542	71.620 68.570
0.8	0	-	-	-	89.955 84.334	118.330 106.827
	0.001	-	-	-	-	-
0.9		-	-	-	-	158.176 151.420
	0.001	-	-	-	-	-
1.0	0	-	-	-	-	-
	0.001	-	-	-	-	-
$x_1 = 0.8$			$x_\beta = 0$		$r_\beta^2 = 0.00324$	

TABLE 54 $\mu b \omega_h$ FOR BENDING-AILERON FLUTTER
WADC TN 57-310 65

ω_β/ω_h	δ/μ μM	40	80	120	240	400
0	0	24.927 18.570	35.735 25.860	43.952 31.518	62.415 44.362	80.708 57.164
	0.001	24.275 18.187	33.840 24.774	40.416 29.491	52.022 38.265	57.060 42.666
0.3	0	25.782 19.629	37.052 27.266	45.604 33.209	64.803 46.711	83.817 60.176
	0.001	25.110 19.220	35.091 26.112	41.943 31.058	54.030 40.253	59.286 44.847
0.4	0	26.381 20.651	38.030 28.598	46.847 34.802	66.620 48.916	86.191 62.998
	0.001	25.697 20.217	36.027 27.378	43.102 32.531	55.583 42.111	61.029 46.877
0.5	0	26.849 22.444	39.031 30.820	48.176 37.432	68.629 52.520	88.848 67.596
	0.001	26.161 21.965	37.001 29.485	44.369 34.955	57.368 45.130	63.095 50.150
0.6	0	- -	38.013 36.116	47.890 42.974	68.938 59.671	89.528 76.560
	0.001	- -	36.057 34.548	44.233 40.043	57.962 51.042	64.157 56.389
0.7	0	- -	- -	- -	- -	- -
	0.001	- -	- -	- -	- -	- -
0.8	0	- -	- -	- -	- -	- -
	0.001	- -	- -	- -	- -	- -
$x_1 = 0.8$		$x_\beta = 0.01$		$r_\beta^2 = 0.00324$		

TABLE 55 $\frac{\mu b \omega_h}{a}$ FOR BENDING-AILERON FLUTTER

No real solutions for values of $\frac{\omega_\beta}{\omega_h}$ above 0.8 for the range of μM considered

ω_B/ω_h	$\frac{8}{\mu} \mu M$	40	80	120	240	400
0	0	23.049 19.606	33.366 27.035	41.137 32.871	58.539 46.169	75.755 59.447
	0.001	22.465 19.185	31.652 25.856	37.926 30.682	49.043 39.635	54.006 44.047
0.3	0	- -	32.806 29.751	40.758 35.896	58.310 50.150	75.589 64.461
	0.001	- -	31.159 28.430	37.654 33.457	49.049 42.929	54.232 47.549
0.4	0	- -	- -	- -	- -	- -
	0.001	- -	- -	- -	- -	- -
$x_1 = 0.8$			$x_B = 0.014$		$r_B^2 = 0.00324$	

TABLE 56 $\frac{\mu b \omega_h}{a}$ FOR BENDING-AILERON FLUTTER
No real solutions for values of $\frac{\omega_B}{\omega_h}$ above 0.4

ω_β/ω_a	δ/μ μM	40	80	120	240	400
0	0	28.392 22.360	40.919 30.999	50.402 37.736	71.671 53.057	92.725 68.341
	0.001	27.730 22.036	38.988 30.213	46.788 36.257	60.953 48.451	68.050 56.781
0.3	0	30.218 23.266	43.567 32.242	53.673 39.243	76.334 55.167	98.764 71.054
	0.001	29.519 22.968	41.521 31.398	49.838 37.659	64.946 50.256	72.538 58.774
0.4	0	31.854 24.076	45.948 33.348	56.616 40.583	80.533 57.041	104.204 73.463
	0.001	31.121 23.759	43.793 32.455	52.571 38.910	68.511 51.872	76.507 60.581
0.5	0	34.313 25.292	49.540 35.000	61.060 42.581	86.880 59.833	112.429 77.049
	0.001	33.525 24.947	47.211 34.037	56.683 40.781	73.855 54.293	82.409 63.308
0.6	0	38.043 27.143	55.019 37.498	67.849 45.596	96.589 64.035	125.018 82.445
	0.001	37.166 26.756	52.409 36.430	62.934 43.608	81.942 57.957	91.256 67.457
0.7	0	43.934 30.156	63.760 41.516	78.709 50.429	112.162 70.753	145.231 91.059
	0.001	42.903 29.703	60.664 40.283	72.866 48.146	94.722 63.829	105.077 74.123
0.8	0	53.483 36.007	78.366 49.098	97.000 59.479	138.573 83.241	179.600 107.029
	0.001	52.185 35.420	74.384 47.547	89.448 56.636	115.989 74.736	127.788 86.474
0.85	0	58.777 42.325		108.905 68.437		
	0.001	57.349 41.580	83.081 54.841	100.237 65.016	130.108 85.328	142.933 98.374
0.9	0	- -	- -	- -	154.383 128.525	202.980 162.901
	0.001	- -	- -	- -	128.608 115.041	142.141 131.861
$x_1 = 0.8$		$x_2 = 0$		$\delta^2 = 0.001, 96$		

$x_0 = 0.4$

TABLE 57

$\mu b \omega_a$

FOR TORSION-AILERON FLUTTER

No real solutions at $\frac{\omega_\beta}{\omega_a} = 1.0$

$x_0 = 0.36$

No real solutions

$x_1 = 0.8$	$x_\beta = 0.01$	$r_\beta^2 = 0.001,96$
-------------	------------------	------------------------

$x_0 = 0.4$

$r_\alpha^2 = 0.36$

TABLE 58 $\frac{\mu b \omega_\alpha}{a}$ FOR TORSION-AILERON FLUTTER

No real solutions

$x_1 = 0.8$	$x_\beta = 0.014$	$r_\beta^2 = 0.001,96$
$x_o = 0.4$		$r_a^2 = 0.36$

TABLE 59 $\frac{\mu b \omega a}{a}$ FOR TORSION-AILERON FLUTTER

ω_β/ω_a	δ/μ μM	40	80	120	240	400
0	0	22.809 17.117	32.612 23.917	40.081 21.180	56.875 41.113	78.319 52.998
	0.001	22.290 16.926	31.110 23.367	37.276 28.141	48.587 37.851	54.503 44.754
0.3	0	24.283 17.772	34.731 24.825	42.689 30.285	60.582 42.664	78.319 54.996
	0.001	23.735 17.565	33.139 24.233	39.715 29.169	51.789 39.175	58.139 46.621
0.4	0	25.603 18.354	36.631 25.630	45.029 31.264	63.911 44.039	82.262 56.765
	0.001	25.027 18.134	34.955 25.003	41.895 30.083	54.637 40.359	61.339 47.530
0.5	0	27.584 19.222	39.488 26.827	48.551 32.717	68.922 46.078	89.110 59.389
	0.001	26.964 18.984	37.677 26.150	45.162 31.446	58.887 42.130	66.069 49.528
0.6	0	30.580 20.529	43.821 28.621	53.895 34.895	76.534 49.128	98.965 63.312
	0.001	29.887 20.264	41.792 27.873	50.095 33.492	65.268 44.798	73.097 52.561
0.7	0	35.279 22.616	50.657 31.469	62.342 38.342	88.582 53.948	114.573 69.507
	0.001	34.462 22.309	48.252 30.610	57.832 36.738	75.206 49.033	83.895 57.402
0.8	0	42.853 26.490	61.838 36.675	76.219 44.618	108.458 62.688	140.360 80.721
	0.001	41.813 26.105	58.748 35.617	70.409 42.654	91.232 56.731	100.999 66.220
0.85	0	47.407 30.278				
	0.001	46.227 29.815	65.357 40.369	78.414 48.222	101.466 63.929	111.796 74.463
0.9	0	- -	69.280 53.496	86.653 64.132	124.814 89.017	162.229 114.129
	0.001	- -	65.689 51.866	79.805 61.160	104.156 80.270	114.337 93.590
$x_1 = 0.8$		$x_\beta = 0$		$\beta^2 = 0.003, 24$		

$x_0 = 0.4$
TABLE 60

$\frac{\mu b \omega_a}{a}$

$x_0 = 0.36$
FOR TORSION-AILERON FLUTTER

No real solutions at $\frac{\omega_\beta}{\omega_a} = 1.0$

ω_β/ω_a	δ/μ μM	40	80	120	240	400
0	0	25.995 15.373	37.022 21.561	45.446 26.335	64.417 37.144	83.238 47.901
	0.001	25.339 15.146	35.124 20.917	41.909 25.132	54.037 33.491	59.704 39.088
0.3	0	26.587 16.226	37.912 22.728	46.557 27.750	66.017 39.124	85.318 50.447
	0.001	25.919 15.980	35.974 22.036	42.942 26.457	55.398 35.210	61.229 41.034
0.4	0	26.789 17.069	38.259 23.873	47.006 29.134	66.683 41.056	86.194 59.929
	0.001	26.123 16.805	36.318 23.132	43.382 27.754	56.024 36.889	61.977 42.936
0.5	0	26.397 18.592	37.851 25.900	46.561 31.569	66.128 44.437	85.514 57.262
	0.001	25.756 18.297	35.972 25.077	43.041 30.040	55.731 39.842	61.784 46.303
0.6	0	-	-	-	58.495 54.126	76.198 63.413
	0.001	-	-	-	-	-
$x_1 = 0.8$		$x_\beta = 0.01$		$r_\beta^2 = 0.003, 24$		

$$x_o = 0.4$$

$$r_a^2 = 0.36$$

TABLE 61 $\frac{\mu b \omega_a}{a}$ FOR TORSION-AILERON FLUTTER

No real solutions for values of $\frac{\omega_\beta}{\omega_a}$ above 0.6

$\omega_\beta/\omega_\alpha$	δ/μ μM	40	80	120	240	400
0	0	23.123 16.133	33.051 22.543	40.617 27.503	57.633 38.748	74.502 49.948
	0.001	22.576 15.869	31.452 21.804	37.627 26.130	48.814 34.624	54.403 40.127
0.3	0	21.763 17.992	31.421 24.890	38.717 30.286	55.071 42.565	71.256 54.819
	0.001	21.629 17.689	29.957 24.052	35.966 28.734	46.901 37.933	52.509 48.852
$x_1 = 0.8$		$x_\beta = 0.014$		$r_\beta^2 = 0.003, 24$		

$$x_0 = 0.4$$

$$r_\alpha^2 = 0.36$$

TABLE 62 $\frac{\mu b \omega_\alpha}{a}$ FOR TORSION-AILERON FLUTTER

No real solutions for $\frac{\omega_\beta}{\omega_\alpha}$ above 0.3

BIBLIOGRAPHY

1. Theodorsen, T. and Garrick, I. E., A Theoretical and Experimental Investigation of the Flutter Problem. NACA Rept. 685, 1940.
2. Hayes, W. D., On Hypersonic Similitude. Quarterly of Applied Mathematics, Vol. 5, No. 1, pp. 105-106, April, 1947.
3. Lighthill, M. J., Oscillating Airfoils at High Mach Numbers. Journal of the Aeronautical Sciences, Vol. 20, No. 6, pp. 402-406, June, 1953.
4. Zartarian, G., Heller, A., and Ashley, H., Application of Piston Theory to Certain Elementary Aeroelastic Problems. Proceedings of the Second Midwestern Conference on Solid Mechanics and the Fourth Midwestern Conference on Fluid Mechanics, Purdue University, September, 1955.
5. Ashley, H., and Zartarian, G., Piston Theory-A New Aerodynamic Tool for the Aeroelastician. Journal of the Aeronautical Sciences, Vol. 23, No. 12, pp. 1109-1118, December, 1956.
6. Garrick, I. E. and Rubinow, S. I., Flutter and Oscillating Air-Force Calculations for an Airfoil in Two-Dimensional Supersonic Flow. NACA Rept. 846, 1946.

APPENDIX

The use of the parameters $\mu b \omega_a / a$ and μM to plot a flutter boundary enable one to plot the requirements of the aircraft and the flutter boundary on the same graph. For example, Fig. 2 shows the region

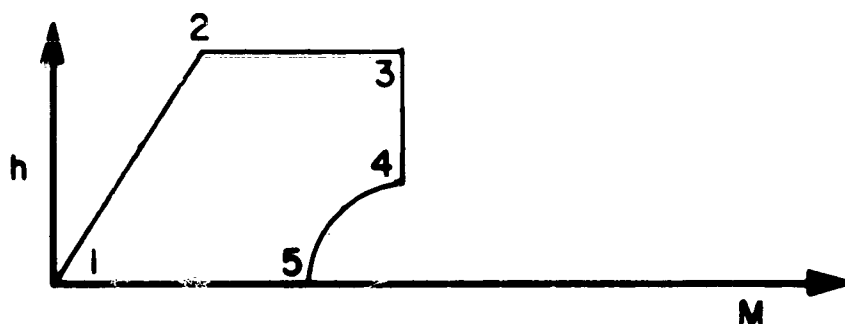


Fig. 2

Graph of Flight Capability of Typical Aircraft
in Terms of Altitude and Mach Number

of expected flight capability for a typical aircraft on an altitude versus Mach number plot. After setting the wing configuration (which includes b , ω_a and m_o) of the aircraft involved, Fig. 2 may be redrawn on a $\mu b \omega_a / a$ versus μM plot and should look something like the sketch in Fig. 3.

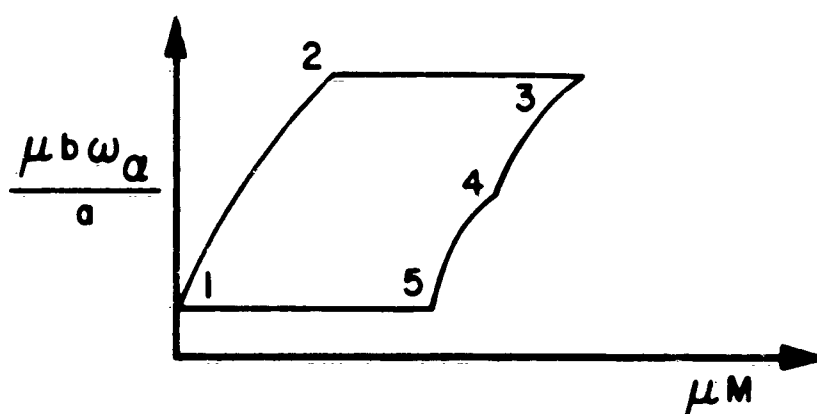


Fig. 3

Flight Capability of Typical Aircraft
in Terms of μM and $\mu b \omega_a / a$

Finally, if we superimpose the flutter boundary on the graph of Fig. 3, we will have a sketch similar to the one shown in Fig. 4. This diagram immediately

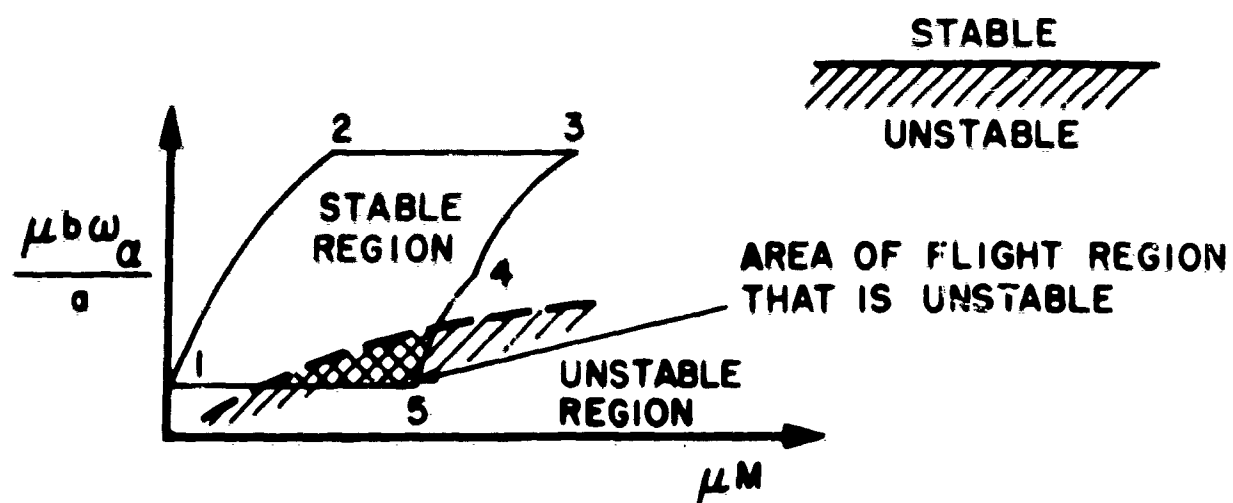


Fig. 4

Flutter Boundary Superimposed on Flight Boundary
for Typical Aircraft in Terms of μM and $\mu b \omega_a/a$

shows what part of the required flight region of the specific airplane configuration is unstable.