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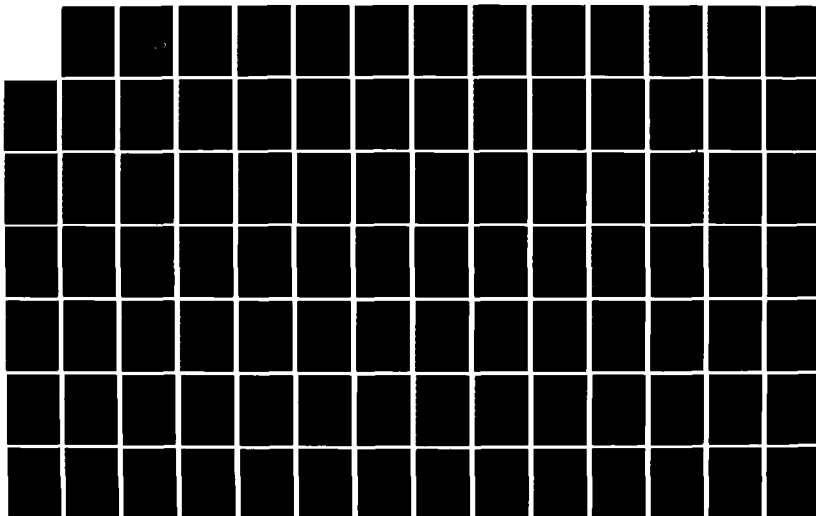
KRASH 85 USER'S GUIDE - INPUT/OUTPUT FORMAT(U)
LOCKHEED-CALIFORNIA CO BURBANK M A GAMON ET AL. JUL 85
LR-30777 DOT/FAA/CT-85-10 DTFA03-83-C-00004

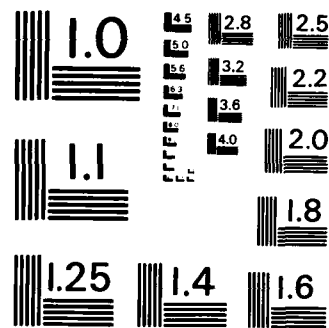
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NATIONAL BUREAU OF STANDARDS-1963-A

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DOT/FAA/CT-85/10
Technical Center
Atlantic City Airport,
N.J. 08405

KRASH 85 User's Guide — Input/Output Format

AD-A161 801

Max Gamon
Gil Wittlin
Bill LaBarge

Prepared by
Lockheed-California Company
Burbank, California

July 1985
Final Report

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Abstract This document describes program KRASH as modified under Contract DTFA03-84-C-00004. Updated version is denoted KRASH85. This document is a User's Guide and defines input and output formats appropriate for KRASH85. Features that are incorporated into KRASH85 include: • An improved plastic hinge moment algorithm, • Gear-oleo metering pin coding, • Load-interaction curves, • An expanded initial conditions subroutine (combined with NASTRAN) • A comprehensive energy balance, • Center of gravity (c.g.) displacement, velocity, acceleration and force time histories, • Revised vertical beam orientation coding, • Provision to save data for post-processing i.e., acceleration, mass location and forces, • Provisions to input preprocessed data, • A corrected uncoupled KR curve unloading/reloading algorithm, • Provisions to define a tire spring (remains normal to the ground plane), • Provisions to number the masses to an arbitrary sequence • An option to compute section shear and moment distributions					
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FOREWORD

This report was prepared by the Lockheed-California Company under Contract DTFA03-84-C-00004. The report contains a description of the effort performed as part of Tasks II, III and IV and covers the period from January 1984 to September 1984. The work was administered under the direction of the Federal Aviation Administration with L. Neri acting as Technical monitor.

The program leader was Gil Wittlin of the Lockheed-California Company. M. A. Gamon and W. L. LaBarge of the Lockheed-California Company refined program KRASH. P. Rohrer of the Lockheed-California Company provided valuable computer programming support. The Lockheed effort was performed in the Flutter and Dynamics Department.

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TECHNICAL SUMMARY

This document describes program KRASH as modified under Contract DTFA03-84-C-00004. The updated version is denoted KRASH85. This document is a User's Guide and defines the input and output formats appropriate for KRASH85.

Features that are incorporated into KRASH85 include:

- An improved plastic hinge moment algorithm
- Gear-oleo metering pin coding
- Load-interaction curves
- An expanded initial conditions subroutine (combined with NASTRAN)
- A comprehensive energy balance
- Center of gravity (c.g.) displacement, velocity, acceleration and force time histories
- Revised vertical beam orientation coding
- Provision to save data for post-processing i.e., acceleration, mass location and forces
- Provisions to input preprocessed data
- A corrected uncoupled KR curve unloading/reloading algorithm
- Provisions to define a tire spring (remains normal to the ground plane)
- Provisions to number the masses in an arbitrary sequence
- An option to compute section shear and moment distributions

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EXECUTIVE SUMMARY

Program KRASH, originally developed under Federal Aviation Administration sponsorship for predicting the response of general aviation airplanes to an impact environment, has been enhanced to include features that would facilitate the modeling of transport category airplanes. This document is the User's Guide which defines the input and output formats appropriate for this new version of Program KRASH known as KRASH 85.

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SECTION 1

INTRODUCTION

Program KRASH, developed under a previous Federal Aviation Administration (FAA) sponsored contract DOT-FA75-WA3707 has been in the public domain since 1979. In subsequent years changes to enhance its usage have occurred. Recently, KRASH has been applied to modeling transport airplanes for impact conditions. Many of the recent program changes that have occurred are designed to facilitate modeling transport airplanes. The following modifications have been incorporated into KRASH85 and used recently to model transport category aircraft:

- Improved plastic hinge moment algorithm
- Gear oleo metering pin
- Load interaction curves
- Expanded Initial Condition Subroutine
- Arbitrary numbering of lumped mass points

Other modifications provide general enhancement capability and include:

- Comprehensive energy balance
- Computation of c.g. time histories
- Revised vertical beam orientation coding
- Post Processing of data, i.e., acceleration, mass location and forces
- Corrected uncoupled KR curve unloading/reloading algorithm

In addition, miscellaneous coding corrections have been made. The current version is denoted KRASH85.

This document is the User's Guide and is limited to a description of the input-output format for KRASH85.

SECTION 2

USER'S GUIDE

2.1 OVERALL KRASH85 ANALYSIS SYSTEM

The overall KRASH85 analysis system consists of two separate KRASH programs called KRASHIC and KRASH85, plus a NASTRAN program denoted herein as MSCTRAN. The NASTRAN program used in this system is MSC/NASTRAN Version 63 (Aug 1, 1983). KRASHIC and MSCTRAN are used only if balanced initial conditions are required; KRASH85 is the normal KRASH time-history program. If KRASHIC and MSCTRAN are not used, then at time zero the beams in the analytical model will all have zero internal deflections and loads. The model will be located just above the ground and in the proper attitude, as specified in the input data. This initial balance is acceptable for certain types of problems, primarily those in which the aerodynamic loads on the vehicle are zero. For that situation, the lumped masses in the model are all accelerating downward at $1g$ (free-falling), and the internal beam loads and deflections are actually zero.

If nonzero aerodynamic forces are present, then the initial beam loads and deflections are not zero. Nevertheless, execution of KRASH85 by itself will automatically set the beam loads and deflections at zero. If this is done with nonzero aerodynamic forces, the system will be out of balance at time zero. In this situation, the dynamic response will be the result of two phenomena:

- Dynamic response to the ground impact
- Dynamic response to the initial imbalance

The latter response is not desired, and can obscure the desired response or confuse the interpretation of the output data. The proper solution of this problem requires that the analytical model be in equilibrium at time zero with nonzero internal beam loads and compatible deflections.

This is essentially a straightforward static loads analysis problem. NASTRAN is used to solve the statics problem, and KRASHIC is used to read KRASH85 input data and convert it into NASTRAN Executive Case Control and Bulk Data Decks. Figure 2-1 shows a flow diagram for the overall KRASH85 analysis system. The options available to the user include the following:

1. Run step 1 only (program KRASHIC)
2. Iterate steps 1 and 2, N times (user-specified)
3. Iterate steps 1 and 2, N times, then run step 3 (KRASH85)
4. Run step 3 (KRASH85) only

The most general case is option 3. The iterations are required for the following reasons. The static solution used in MSCSTRAN is Rigid Format 24, which is a small deflection linear static analysis. This method actually assumes zero deflections for the purposes of calculating transformation matrices for transforming beam loads from beam element axes to the global axis system, which in this case are airplane axes. Therefore, if the deflections from MSCSTRAN are used to relocate the KRASH85 mass points, the KRASH85 calculated beam loads will be proper in beam axes, but when resolved to mass axes will yield a system that is out of balance (since KRASH85 does not assume the deflections are zero when calculating the transformation matrices)

The solution to this problem is to iterate steps 1 and 2, using the calculated deflections from MSCSTRAN to relocate the mass and node points in KRASH at each step. Satisfactory convergence is achieved after about six iterations, and additional accuracy can be achieved by using up to ten iterations. Beyond ten iterations, no further improvement in accuracy can be achieved due to the limitations in the number of digits that are written to the data sets that form the input and output of MSCSTRAN.

The KRASH analysis system shown in figure 2-1 is implemented through Job Control Language (JCL). A job submittal using option 3 with six iterations causes a total of 13 sequential jobs to be executed (6 KRASHIC, 6 MSCSTRAN and 1 KRASH85). While this may sound rather expensive, a typical case

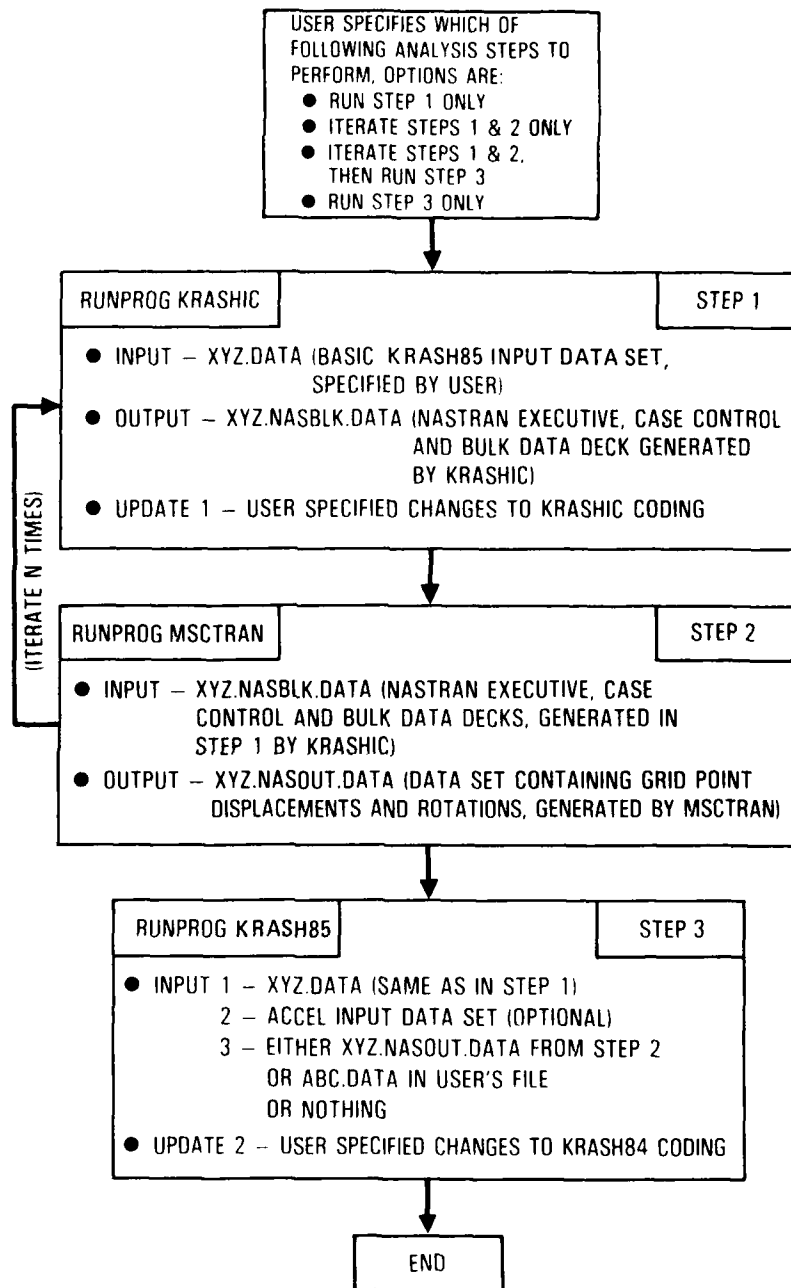


FIGURE 2-1. OVERALL KRASH85 ANALYSIS SYSTEM

(21 mass/27 beam, $\frac{1}{2}$ airplane model) requires only about seven seconds per iteration on an IBM 370/3081, so that the iterated balanced loads can be determined in less than one minute. The JCL is set up so that data sets XYZ.NASBLK.DATA and XYZ.NASOUT.DATA are generated and named automatically, so the process is essentially invisible to the user.

Step 3 (KRASH85) can be executed separately using option 4. When this is done, the user has a choice of what to do for initial conditions. He can specify any data set in his library, or use nothing at all. The latter corresponds to the mode of execution for prior versions of KRASH. Once an initial condition data set (XYZ.NASOUT.DATA) has been generated, the user can execute step 3 only while specifying XYZ.NASOUT.DATA for initial conditions. This will give a valid initial balance as long as modifications to the basic data set (XYZ.DATA) are restricted to items that do not affect the initial balance.

The static loads problem could have been solved entirely within program KRASH, avoiding the complexity of achieving the system shown in figure 2-1 with JCL. However, the technique chosen has the advantage of automatically generating a NASTRAN model from a given KRASH Model. Since XYZ.NASBLK.DATA is a complete NASTRAN input data set in the user's library, the user can easily edit this data set to exercise other NASTRAN capabilities. Examples of other NASTRAN features that could prove useful include eigenvalue calculations and model plotting.

Figure 2-2 is a copy of the information displayed on a computer terminal during an option 3 run submittal. The items enclosed in rectangular brackets are the user responses. These are now discussed in detail. Some of the comments are of necessity applicable only to the Lockheed IBM 370/3081 installation, but are included to give some perspective on an actual application.

<u>User Response</u>	<u>Description</u>
runprog krashi x(1)	This is the initial command to invoke the Krash analysis system in Figure 2-1.

ENTER TIME

ENTER LINES

WOULD YOU LIKE EXPRESS, STANDARD
OR DEFERRED(VERNIGHT) TURNAROUND
FOR YOUR JOB? ENTER E, S OR D

Enter number

- 1 run KRASHIC only
- 2 iterate KRASHIC and MSCTRAN only
- 3 iterate KRASHIC and MSCTRAN, then run KRASH85
- 4 run KRASH85 only

Enter name of input data

Enter the number of times to cycle through
KRASHIC and MSCNASTRAN

print execution results only for
the last iteration? (Y/N)

are you using B720.ICITER.NASOUT.DATA
with the input data for the 1st iteration? (Y/N)

KRASHIC ITERATION #1

If temporary source changes then enter name
of PAN updata data set.
If none hit enter.

Suppress compile listing ? (Y/N)

KRASHMSC ITERATION # 1
KRASHIC ITERATION # 2
KRASHMSC ITERATION # 2

FIGURE 2-2. SAMPLE KRASH85 JOB SUBMITTAL (SHEET 1 OF 2)

KRASHIC ITERATION # 3
KRASHMSC ITERATION # 3
KRASHIC ITERATION # 4
KRASHMSC ITERATION # 4
KRASHIC ITERATION # 5
KRASHMSC ITERATION # 5
KRASHIC ITERATION # 6
KRASHMSC ITERATION # 6
KRASHIC ITERATION # 7
KRASHMSC ITERATION # 7
KRASHIC ITERATION # 8
KRASHMSC ITERATION # 8
KRASHIC ITERATION # 9
KRASHMSC ITERATION # 9
KRASHIC ITERATION # 10
KRASHMSC ITERATION # 10

KRASH84

is this a checkpoint/restart run? (Y/N)

If temporary source changes then enter name of
update data set
If not then hit enter

HIT "RETURN" KEY IF NO DATA SET:

(A) enter name of 2nd input data set of MASS ACCELERATIONS

(b) enter name of output data set of MASS ACCELERATIONS

(c) enter name of MASS and/or NODE POINT DISPLACEMENTS
(GRAPHICS POST PROCESSOR DATA)

How many copies of the printed output do you want?

1

SUPPRESS COMPILE LISTING ? (Y/N)

y

JOB E434367L SUBMITTED BY USER E434367

READY

FIGURE 2-2. SAMPLE KRASH85 JOB SUBMITTAL (SHEET 2 OF 2)

<u>User Response</u>	<u>Description</u>
10	Time limit for run = 10 minutes (actual execution time was less than three minutes)
50	Output print limited to 50000 lines (actual output is 21000 lines, about 1.5 inches thick).
d	Overnight (deferred) turnaround requested. (For runs less than 10 minutes, express turnaround is allowed. Results available within one to two hours).
3	Option 3 is chosen.
B720.ICITER.DATA	Basic KRASH85 input data set. This corresponds to XYZ.DATA in figure 2-1.
10	Number of iterations of steps 1 and 2.
y	Printout of KRASHIC and MSCTRAN is suppressed for the first nine iterations. Only the results for the last iteration are printed. Considerable output print will be generated if the results for all iterations are printed. (y = yes)
n	It is possible to start the first iteration with an existing data set of NASTRAN output deflections. For example, five iterations could be run at one time, and five more at a later time. This option was not invoked for this example. (n = no)
kic.kvb.data	This is the name of a PANVALET update data set which is used to revise the source code for KRASHIC. If no revisions are specified, then hit carriage return (CR).
y	A compiled listing of the subroutines changed in the previous step can be obtained. In the example, the listing is suppressed. (y = yes)
-	The terminal displays KRASHMSC ITERATION #1, etc., as the JCL for the sequential runs is being generated.
n	The checkpoint/restart capability of KRASH85 is not used for this run. (n = no)

<u>User Response</u>	<u>Description</u>
k83.iere.data	This is the name of a PANVALET update data set which is used to revise the source code for KRASH85. If no revisions are specified, then hit carriage return (CR).
DSA	In the example shown, the CR was hit for each of these, so no data sets were specified. DSA, DSB, and DSC are indicated here to illustrate where these are specified in the input. DSA, DSB, and DSC are described in the input format description.
DSB	
DSC	
l	One copy of the output print requested.
y	A compiled listing of the subroutines of KRASH85 that are revised can be obtained. In this example, the listing is suppressed. (y = yes)

The KRASH85 analysis system described herein is capable of achieving a balanced set of initial conditions only for the situation where the airplane starts completely off the ground. If any part of the airplane is initially in contact with the ground (any external springs initially deflected), the current code cannot balance the airplane.

2.2 INPUT

The input data format is described in detail in this section and is shown in table 2-1 and figure 2-3. Table 2-1 gives a quick overview of the input data sequence, while figure 2-3 is a complete layout of the input data format. The data discussed in this section correspond to XYZ.DATA in Section 2.1. Unless otherwise specified, all quantities are input to inch, pound, second, and radian units. Two formats are used for the majority of the data; 7E10.0 for fixed-point and scientific-notation input, and 15 for integers. As an example of the former, the number 126.08 can be input in the following ways:

		1	2	6	.	0	8		
		1	2	6	.		8		

		1	.	2	6	0	8		E	2
		1	2	6	0	8	.	E	-	2

TABLE 2-1. KRASH INPUT FORMAT SEQUENCE

Card Sequence No.(s)	Required (R) or Optional (O)	Card Type Identifier	Identifier is Specified on Card No.	General Description of Data
10-170	R	-	-	Title, case control, initial conditions
200	R	NM	40	Mass data
300	O	NNP	40	Node point data
400	O	NTAB	70	Acceleration transfer correspondence data
500	O	NMSAV	80	Mass acceleration save data
600	O	NNPSAV	80	Node point acceleration save data
700-800	O	NSP	40	External spring data
900	R	NB	40	Internal beam data
1000	O	NMTL	40	Material data
1100	O	NPIN	40	Beam pinned-end and plastic hinge data
1200	O	NUB	40	Unsymmetrical beam data (axial only)
1290-1500	O	NOLED	40	Oleo type beam element data
1600	R	-	-	Internal beam damping ratio
1700	O	ND	40	Non-standard internal beam damping ratios
1800-1900	O	NLB	40	Nonlinear beam data (KR tables)
2000	O	MVP	40	Mass penetration volume definition
2100	O	NDRI	40	Dynamic Response Index (DRI) definitions
2200	O	NVCH	40	Volume change data
2300	O	NVBM	50	Non-standard maximum positive beam deflections.
2400	O	NVBMN	50	Non-standard maximum negative beam deflections.
2500	O	NFBM	50	Non-standard maximum positive beam loads
2600	O	NFBMN	50	Non-standard maximum negative beam loads
2700	O	NSCV	60	Sign convention vectors for load-interaction curves
2800-3000	O	NLIC	60	Load-interaction curve data
3100	O	NHI	50	Non-zero mass angular momenta, lift constant, or inertia cross products
3200	O	NPH	50	Non-zero initial mass orientation Euler angles
3300	O	NAERO	50	Mass aerodynamic data
3400-3500	O	NACC	40	Mass acceleration or load input time-histories
3600	O	NKM	50	Direct input of beam stiffness matrices
3700-3800	O	NPLT	140	Position plot data
3900	O	NMEP	140	Mass point printer plot data
4000	O	NNEP	140	Node point printer plot data
4100	O	NBFP	140	Beam loads printer plot data
4200	O	NBDP	140	Beam deflection printer plot data
4300	O	NSTP	140	Beam stress ratio printer plot data
4400	O	NSEP	140	External spring load/deflection printer plot data
4500	O	NENP	140	Beam strain/damping energy printer plot data
4600	O	NDRP	140	DRI printer plot data
4700	R	-	-	End of data set card

GENERAL PURPOSE DATA SHEET

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A DIVISION OF LOCKHEED CORPORATION

TITLE: KRASH85 INPUT FORMAT										PAGE 1		OF 7							
PREPARED BY					CHECKED BY					DATE		JOB NO.		GROUP					
DATE					DATE					W.O.		EWA		ID		SEQ			
1	5	7	10	15	20	25	30	35	40	45	50	55	60	65	70	73	76	77	80
TITLE CARD																			
TITLE CARD																			
12345678901123456789012345678901234567890123456789012																			
DUMMY																			
NM NSP NB NUB NNP NIPIN NJUB NORT NQLEONACC MVP NYVCH NMTL ND																			
DUMMY																			
NVBMJFBMNBMBNFBMNU NKM NHI NPH NTOL1 NTOL2 NTOL3 NSC NJC NAERDNBOMB																			
DUMMY																			
NISC/NLJTCNRCGA NBAL ICD ICITER																			
DUMMY																			
1 5 7 10 15 20 25 30 35 40 45 50 55 60 65 70 73 76 77 80																			
(CSEN) (RNIN) (RNOUT) NMSAV NDTSAV NWRFLG NOTGRA																			
DUMMY																			
CASEIN RUNIN MSECIN																			
CASEOUT RUNOUT MSECOUT(1) MSECOUT(2)																			
1 5 7 10 15 20 25 30 35 40 45 50 55 60 65 70 73 76 77 80																			
DUMMY DT TMAX PLWT FCUT RUNMOD																			
DP/DT																			
DUMMY BLANK CARD																			
1 5 7 10 15 20 25 30 35 40 45 50 55 60 65 70 73 76 77 80																			

FORM 8104-2

FIGURE 2-3. KRASH85 INPUT FORMAT (SHEET 1 OF 7)

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A DIVISION OF LOCKHEED CORPORATION**

FORM 9104-2

FIGURE 2-3. KRASH85 INPUT FORMAT (SHEET 2 OF 7)

GENERAL PROPOSE DATA SHEET

LOCKHEED-CALIFORNIA COMPANY
A DIVISION OF LOCKHEED CORPORATION

PAGE 3 OF 7

TITLE:		PREPARED BY	DATE	CHECKED BY	DATE	JOB NO.	GROUP	W.O.	EWA	ID	SEQ								
1	5	7	10	15	20	25	30	35	40	45	50	55	60	65	70	73	76	77	80
DUMMY	(2X NSP CARDS FOLLOW)																		
M I	K	XLBAR	XMI																
SI	SA		SB																
DUMMY	(NB CARDS FOLLOW)																		
M I	NI	J	AA																
DUMMY	(NMPL CARDS FOLLOW)																		
MC	EE		GG																
DUMMY	(NIPIN CARDS FOLLOW)																		
M I	NI	J	PZI	PYJ	PZJ														
DUMMY	(NUB CARDS FOLLOW)																		
M I	NI	J	DB																
DUMMY	(2X NPLED + 1 + METERING PIN CARDS FOLLOW)																		
ALPHA	NMPTAB																		
M I	NI	J	FAO																
M I	NI	J	BOLEO																
M I	NI	J	BOLEO																
NPITSM																			
YOLEO	BOLEO																		
DUMMY	(1 CARD FOLLOWS)																		
DAMPE																			
DUMMY	(ND CARDS FOLLOW)																		
M I	NI	J	CBAR																

FORM 8104-2

FIGURE 2-3. KRASH85 INPUT FORMAT (SHEET 3 OF 7)

GENERAL APOSE DATA SHEET

LOCKHEED-CALIFORNIA COMPANY
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TITLE:		PREPARED BY	DATE	CHECKED BY	DATE	JOB NO.	GROUP	PAGE	OF										
						W.O.	EWA	4	7										
1	5	7	10	15	20	25	30	35	40	45	50	55	60	65	70	73	76	77	80
DUMMY	(N1B +	CARDS FOLLOW)																	
M I	N I	J	L	NP	LDP	LDP													
XKRI	KRI																		
DUMMY	(1 CARD	FOLLOWS IF MYP ≠ 0)																	
YU	XP	YN	YP	ZN															
1	5	7	10	15	20	25	30	35	40	45	50	55	60	65	70	73	76	77	80
DUMMY	(DRI SPEC. CARD(S)	FOLLOW)																	
I ₁	J ₁																		
DUMMY	(NVCN	CARDS FOLLOW)																	
I ₁	I ₂	I ₃	I ₄	I ₅	I ₆	I ₇	I ₈												
1	5	7	10	15	20	25	30	35	40	45	50	55	60	65	70	73	76	77	80
DUMMY	(NVEB	CARDS FOLLOW)																	
M I	N I	J	NMAX1	VMAX2	VMAX3	VMAX4	VMAX5	VMAX6											
DUMMY	(NVEB	CARDS FOLLOW)																	
M I	N I	J	VMAXN1	VMAXN2	VMAXN3	VMAXN4	VMAXN5	VMAXN6											
DUMMY	(NVEB	CARDS FOLLOW)																	
1	5	7	10	15	20	25	30	35	40	45	50	55	60	65	70	73	76	77	80
M I	N I	J	FMAX1	FMAX2	FMAX3	FMAX4	FMAX5	FMAX6											
DUMMY	(NVEB	CARDS FOLLOW)																	
M I	N I	J	FMAXN1	FMAXN2	FMAXN3	FMAXN4	FMAXN5	FMAXN6											
DUMMY	(NVEB	CARDS FOLLOW)																	
1	5	7	10	15	20	25	30	35	40	45	50	55	60	65	70	73	76	77	80

FORM 8104-2

FIGURE 2-3. KRASH85 INPUT FORMAT (SHEET 4 OF 7)

LOCKHEED-CALIFORNIA COMPANY
A DIVISION OF LOCKHEED CORPORATION

FORM 9104.2

FIGURE 2-3. KRASH85 INPUT FORMAT (SHEET 5 OF 7)

LOCKHEED-CALIFORNIA COMPANY
A DIVISION OF LOCKHEED CORPORATION

[illegible]

FORM 810M-2

FIGURE 2-3. KRASH85 INPUT FORMAT (SHEET 6 OF 7)

GENERAL PROPOSE DATA SHEET

LOCKHEED-CALIFORNIA COMPANY
A DIVISION OF LOCKHEED CORPORATION

TITLE		PREPARED BY		DATE		CHECKED BY		DATE		JOB NO		GROUP		PAGE		OF	
														7		7	
														ID		SEQ	
														EWA			
1	DUMMY	15	20	25	30	35	40	45	50	55	60	65	70	73	76	77	80
	(NSEP CARDS FOLLOW)																
	IJ BFP1 BFP2 BFP3 BFP4																4100
	DUMMY																
	(NSEP CARDS FOLLOW)																
	IJ BFP1 BFP2 BFP3																4200
	DUMMY																
	(NSEP CARDS FOLLOW)																
1	IJ STP1 STP2 STP3 STP4 STP5	15	20	25	30	35	40	45	50	55	60	65	70	73	76	77	80
	DUMMY																4300
	(NSEP CARDS FOLLOW)																
	I M SEP1 SEP2																4400
	DUMMY																
	(NSEP CARDS FOLLOW)																
1	IJ ENGR ENGR2	15	20	25	30	35	40	45	50	55	60	65	70	73	76	77	80
	DUMMY																4500
	(NDRP CARDS FOLLOW)																
	J																4600
	END																4700

FORM 8104-2

FIGURE 2-3. KRASH85 INPUT FORMAT (SHEET 7 OF 7)

Blank columns are treated as zeros. When the E format is used, the exponent must be right justified in the field. With the I5 integer format, the number must be right justified. The sequence numbers shown in columns 77 through 80 are only for reference purposes within this document. The actual data cards can have any numbering scheme, or no numbers at all, as long as the cards are in the proper order.

The following coordinate systems (figure 2-4) are established to facilitate the derivation of equations for the mathematical model. The input data description specifies the appropriate coordinate systems to be used.

- Ground Coordinate System. - This is a right-handed coordinate system fixed in the ground with the origin at point 0 in figure 2-4. The x-axis is positive forward, the y-axis is positive to the right, and the z-axis is positive downward. The xy-plane ($z = 0$) corresponds to the ground surface. The ground coordinate system is considered an inertial coordinate system for writing the dynamic equations of motion.
- Slope Coordinate System. - This is a right-handed coordinate system fixed in the ground with the origin at point 0 as shown in figure 2-4. The x-axis is positive forward up the slope, the y-axis is positive to the right, and the z-axis is positive downward and perpendicular to the slope. This coordinate system is the same as the ground coordinate system rotated through an angle 'beta', positive clockwise about the ground y-axis. The xy-plane represents a plane inclined at an angle 'beta' with respect to the horizontal ground plane. 'Beta' is a constant input angle that can range from zero to ninety degrees.
- Airplane Coordinate System. - This is a left-handed coordinate system fixed with relation to the airplane with the origin at point H in figure 2-4. The x-axis is positive aft, the y-axis is positive to the left when looking forward, and the z-axis is positive upward. The origin at point H corresponds to zero fuselage station ($FS = 0$), zero buttline ($BL = 0$), and zero waterline ($WL = 0$). This coordinate system is used only to input the location coordinates of the mass points and massless node points since the coordinates of the points are usually available in terms of fuselage station, buttline, and waterline.
- Center-of-Gravity Coordinate System. - This is a right-handed coordinate system fixed with relation to the airplane with the origin at the vehicle c.g., point G. The x-axis is positive forward, the y-axis is positive to the right when looking forward, and the z-axis is positive downward. These axes are parallel to the airplane coordinate system axes.

- Mass Point Coordinate System. - Each mass point has its own right-handed coordinate system fixed with relation to the mass point. The initial orientation of each of these coordinate systems is arbitrary and is specified by means of three input Euler angles for each mass point relating its initial orientation to the center-of-gravity coordinate system since the inertia data are generally available about these axes and the three input Euler angles are zero. The mass point coordinate system is the system used to write Euler's equations of motion for each mass point.
- Beam Element Coordinate System. - This is a right-handed coordinate system with the beam element x-axis along a straight line from the mass point at end 'I' to the mass point at end 'J'. As the mass points move, the beam element coordinate system changes orientation so that the x-axis is always pointing from the mass point at end 'I' to the mass point at end 'J'. If the beam element connects massless node points which are offset from the mass points, then the beam element x-axis always points from the massless node point rigidly attached to the mass point at end 'I' to the massless node point rigidly attached to the mass point at end 'J'.

The beam element y-axis and z-axis are mutually perpendicular. The direction of each is arbitrary and is defined internally within the program. The input data are prepared according to the beam element coordinate systems shown in figure 2-5 (page 2-46).

The following is a detailed description of all the input data requirements.

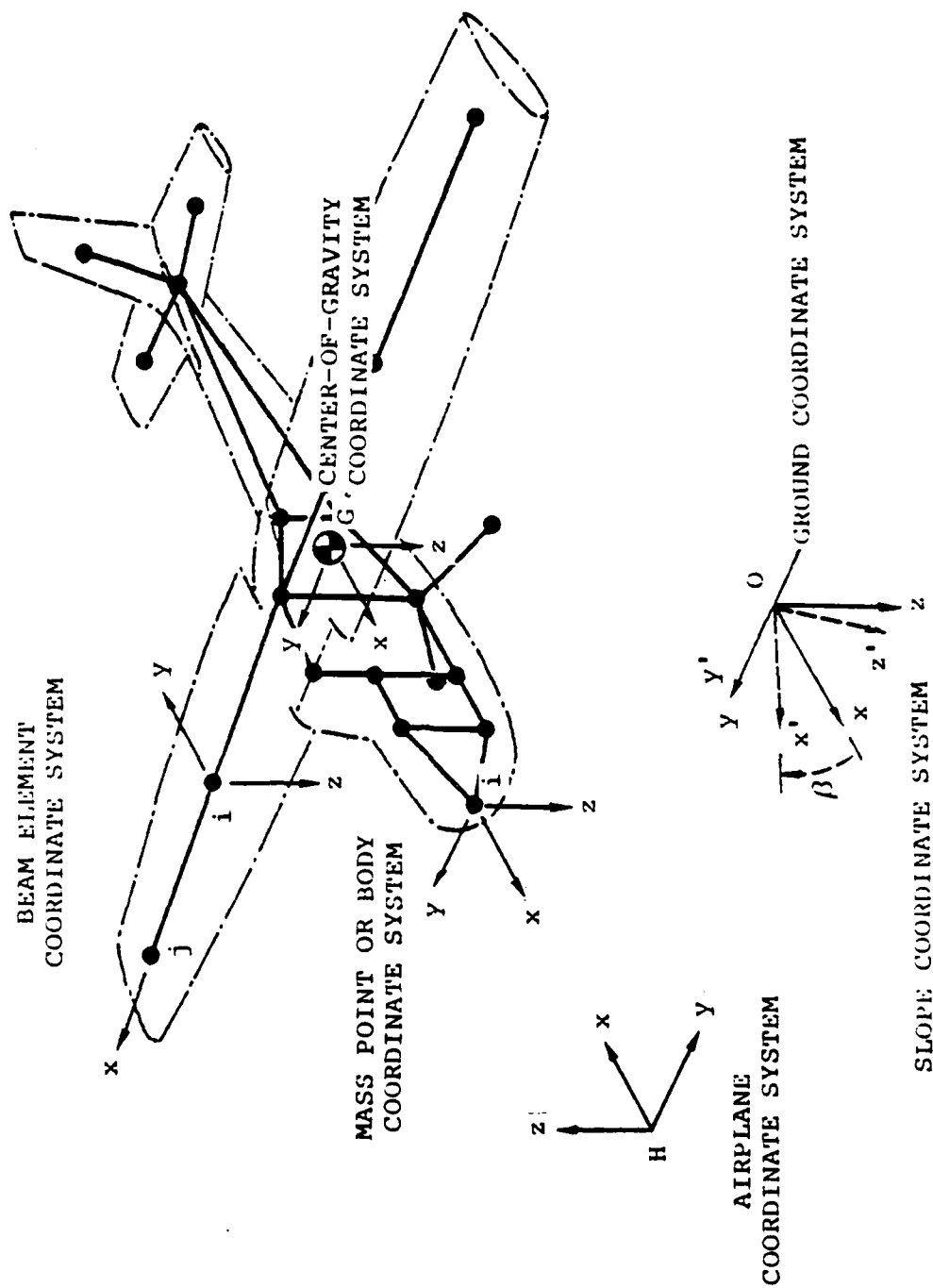


FIGURE 2-4. KRASH85 COORDINATE SYSTEMS

KRASH* INPUT DATA

CARD 0010: **TITLE CARD #1**

DESCRIPTION: Defines an alphanumeric label which will appear as the first line of heading on each page of KRASH* printed output.

FORMAT AND EXAMPLE:

0	1	2	3	4	5	6	7	8
1	2	3	4	5	6	7	8	9
TITLE 1								
SUBSTRUCTURE SECTION IMPACT STUDY								0010

<u>FIELD</u>	<u>CONTENTS</u>
--------------	-----------------

Title1	Alphanumeric Character String
--------	-------------------------------

REMARKS:

- (1) Required data card; however, it may be blank.
- (2) All text material on this card is reproduced at the top of every output page and on every plot.

CARD 0020: **TITLE CARD #2**

DESCRIPTION: Defines an alphanumeric label which will appear as the second line of heading on each page of KRASH printed output.

FORMAT AND EXAMPLE:

0	1	2	3	4	5	6	7	8
1	2	3	4	5	6	7	8	9
TITLE 2								
INITIAL CONDITIONS: 27.5 FPS VERTICAL IMPACT ON RIGID SURFACE								0020

<u>FIELD</u>	<u>CONTENTS</u>
--------------	-----------------

Title2	Alphanumeric Character String
--------	-------------------------------

REMARKS:

- (1) Required data card; however, it may be blank.
- (2) All text material on this card is reproduced at the top of every output page and on every plot.

*KRASH refers to KRASH85 in all subsequent input data sheets

KRASH INPUT DATA

CARD 0030: DUMMY CARD

DESCRIPTION: Defines a numeric heading which will appear on each page of the KRASH printout of the input data deck echo.

FORMAT AND EXAMPLE:

0	1	2	3	4	5	6	7	8
12345678901	2345678901	2345678901	2345678901	2345678901	2345678901	2345678901	2345678901	2345678901
DUMMY								
12345678901	2345678901	2345678901	2345678901	2345678901	2345678901	2345678901	2345678901	2345678901
								0030

<u>FIELD</u>	<u>CONTENTS</u>
Dummy	Numeric String

REMARKS:

- (1) Required data card; however, it may be blank.
- (2) Intent of this data card is to aid the user in verifying the field placement of the input data.

KRASH INPUT DATA

CARD 0040: KRASH MODEL SIZE PARAMETERS

DESCRIPTION: Defines the sizes of the various input parameter data sets for the KRASH model.

FORMAT AND EXAMPLE:

0										1										2										3										4										5										6										7										8									
12345678901										2345678901										345678901										45678901										5678901										678901										78901										8901																			
NM		NSP		NB		NLB		NNP		NPIN		NUB		NDRI		NOLEO		NACC		MVP		NVCH		NMTL		ND		X																																																													
16		10		32		2		6		0		4		0		0		0		0		0		0		1		0040																																																													

<u>FIELD</u>	<u>CONTENTS</u>
NM	Number of Mass Points Per 0200-Series Cards (Maximum Allowed is 80)
NSP	Number of External Crushing Springs Per 0700/0800-Series Cards (Maximum Allowed is 40)
NB	Number of Beam Elements Per 0900-Series Cards (Maximum Allowed is 150)
NLB	Number of Beam Element Nonlinear Degrees-of-Freedom Per 1800-Series Cards (Maximum Allowed is 180)
NNP	Number of Massless Node Points Per 0300-Series Cards (Maximum Allowed is 50)
NPIN	Number of Beam Elements Having at Least One Degree-of-Freedom Pinned Per 1100-Series Cards (Maximum Allowed is 150)
NUB	Number of Axially Unsymmetric Beam Elements Per 1200-Series Cards (Maximum Allowed is 150)
NDRI	Number of DRI Beam Elements Per 2100-Series Cards (Maximum Allowed is 150)
NOLEO	Number of Shock Strut Elements Per 1300 and 1400-Series Cards (Maximum Allowed is 20)
NACC	Number of Enforced Acceleration Time History Tables Per 3400/3500-Series Cards (Maximum Allowed is 100 Input Tables, With a Total of 5000 Time Points)
MVP	Reference Mass Point For Volume Penetration Calculations Per 2000-Series Cards (Maximum Allowed is 1)
NVCH	Number of Volumes For Occupiable Volume Change Calculations Per 2200-Series Cards (Maximum Allowed is 5)
NMTL	Number of Non-Standard Beam Element Materials Per 1000-Series Cards (Maximum Allowed is 10)
ND	Number of Beam Elements With Non-Standard Damping Ratios Per 1700-Series Cards (Maximum Allowed is 150)

- REMARKS:
- (1) Required data card.
 - (2) All entries are right justified integers.
 - (3) 'NM' and 'NB' must be nonzero.
 - (4) Blank entries are read as zero.
 - (5) See Table 2-1 for a summary of model size parameters.
 - (6) Format for this card is 1415.

TABLE 2-2. PROGRAM SIZING CONSTANTS

CONSTANT	MAXIMUM VALUE	DESCRIPTION
NM	80	NUMBER OF MASSES
NSP	40	NUMBER OF EXTERNAL SPRINGS
NB	150	NUMBER OF INTERNAL BEAMS
NLB	180	NUMBER OF NONLINEAR BEAM-DIRECTION COMBINATIONS (KR TABLES)
NHI	80	NUMBER OF MASSES HAVING NON-ZERO He_{xj} , He_{yj} , He_{zj} , I_{xyj} , I_{yzj} , I_{xzj} , OR I_{cj}
MVP	-	REFERENCE MASS NUMBER FOR VOLUME PENETRATION CALCULATIONS
NVCH	5	NUMBER OF VOLUMES FOR OCCUPIABLE VOLUME CHANGE CALCULATIONS
NDRI	150	NUMBER OF DRI BEAM ELEMENTS
NMTL	10	NUMBER OF NON-STANDARD BEAM MATERIALS
NACC	100	NUMBER OF INPUT ACCELERATION TIME-HISTORY TABLES (TOTAL NUMBER OF TIME POINTS = 5000)
NVBM	150	NUMBER OF INTERNAL BEAMS HAVING NON-STANDARD MAXIMUM POSITIVE (NVBM) OR NEGATIVE (NVBMN) DEFLECTIONS FOR BEAM RUPTURE. STANDARD VALUE = 100 (inches OF DEFLECTION AND radians OF ROTATION)
NVBMN	150	
NFBM	150	NUMBER OF INTERNAL BEAMS HAVING NON-STANDARD MAXIMUM POSITIVE (NFBM) OR NEGATIVE (NFBMN) FORCES FOR BEAM RUPTURE. STANDARD VALUE = 1E10
NFBMN	150	
NPH	80	NUMBER OF MASSES HAVING NON-ZERO EULER ANGLES ϕ_1'' , θ_1'' , ψ_1''
ND	150	NUMBER OF INTERNAL BEAMS HAVING DAMPING RATIOS DIFFERENT FROM THAT SPECIFIED ON CARD 1600
NKM	150	NUMBER OF INTERNAL BEAMS FOR WHICH THE FULL 6 x 6 STIFFNESS MATRIX IS DIRECTLY INPUT
NPIN	150	NUMBER OF INTERNAL BEAMS HAVING OTHER THAN FIXED-FIXED END CONDITIONS
NNP	50	NUMBER OF MASSLESS NODE POINTS
NUB	150	NUMBER OF UNSYMMETRICAL BEAMS
NOLFO	20	NUMBER OF SHOCK STRUTS

CARD 0050: KRASH MODEL SIZE PARAMETERS AND CALCULATION FLAGS

FORMAT AND EXAMPLE:

0		1		2		3		4		5		6		7		8	
1	2	3	4	5	6	7	8	9	0	1	2	3	4	5	6	7	8
NVBM	NFBM	NVBMN	NFBMN	NKM	NHI	NPH	NTOL1	NTOL2	NTOL3	NSC	NIC	NAIRO	NBOMB	X			
0	0	0	0	0	0	0	10	50	100	0	0						0050

<u>FIELD</u>	<u>CONTENTS</u>
NVBM	Number of Beam Elements Having Non-Standard Rupture Positive Deflections Per 2300-Series Cards (Maximum Allowed is 150)
NFBM	Number of Beam Elements Having Non-Standard Rupture Positive Forces Per 2500-Series Card (Maximum Allowed is 150)
NVBMN	Number of Beam Elements Having Non-Standard Rupture Negative Deflections Per 2400-Series Card (Maximum Allowed is 150)
NFBMN	Number of Beam Elements Having Non-Standard Rupture Negative Forces Per 2600-Series Cards (Maximum Allowed is 150)
NKM	Number of Beam Elements For Which 6 x 6 Stiffness Matrix is Directly Input Per 3600 Series Cards (Maximum Allowed is 150)
NHI	Number of Mass Points Having Nonzero Aerodynamic Lift Constant, Angular Momenta, or Cross Products of Inertia Per 3100-Series Card (Maximum Allowed is 80)
NPH	Number of Mass Points Having Nonzero Euler Angles For Rotating the Mass Point or Body Coordinate System Relative to The Center-of-Gravity Coordinate System Per 3200-Series Cards (Maximum Allowed is 80)
NTOL1	Percent Allowable Total Energy Growth Above 100 Percent (Default Value is One (1) Percent)
NTOL2	Percent Allowable Individual Negative Strain, Damping, Crushing and Friction Terms of Respective Totals (Default Value is Ten (10) Percent)
NTOL3	Percent Allowable Individual Mass Energy Deviation Above Zero Percent (Default Value is Thirty (30) Percent)
NSC	Flag For Beam Element Stress Calculation: 0 = No 1 = Yes
NIC	Flag For Preliminary Beam Element Failure Load and Deflection Calculations: 0 = No 1 = Yes
NAERO	Number of Masses Having Aerodynamic Data Input Per 3300-Series Card (Maximum Allowed is 80)
NBOMB	Any Nonzero Input Will Override all Energy Growth Error Checks. Run Will Execute to Completion Regardless of Energy Calculations.

- | REMARKS: | |
|----------|--|
| (1) | Required data card; however it may be blank. |
| (2) | All entries are right justified integers. |
| (3) | Blank entries are read as zero. |
| (4) | If any of the allowable errors in energy are exceeded, the analysis terminates automatically at that time, and summary tables and printer plots are generated. |
| (5) | Default values for NVBM and NVBMN are 100 inches or radians. Default values for NFBM and NFBMN are 1E10, lbs or in-lbs. |
| (6) | See Table 2-1 for a summary of model size parameters. |
| (7) | It is recommended that NIC = 1 be used each time if complete beam properties are input (0900-series cards). |
| (8) | Format for this card is 1415. |

KRASH INPUT DATA

CARD 0060: KRASH MODEL SIZE AND PROGRAM CONTROL PARAMETERS

DESCRIPTION: Defines the sizes of input parameter data sets for the KRASH model and controls the output of graphics information and specifies the type of initial conditions to be used.

FORMAT AND EXAMPLE:

0	1	2	3	4	5	6	7	8
1	2	3	4	5	6	7	8	9
NSCV	NLIC	NWRGRA	NBAL	ICD	ICITER			
1	16	0	5	1	1			
								0060

<u>FIELD</u>	<u>CONTENTS</u>
NSCV	Number of User-Specified Sign Convention Vectors, Per 2700-Series Cards, To Be Used in Conjunction With Load-Interaction Curve Data. (Maximum Allowed is 10) NSCV May be Zero.
NLIC	Number of Load-Interaction Curves Per 2800/3000-Series Cards (Maximum Allowed is 40)
NWRGRA	Parameter Which Governs Whether Graphics Data For Postprocessing is Written to The User's Data File. NWRGRA = 0 Results in No Data Being Written to The User's File. Any Nonzero Input Will Result in Mass and Node Point Displacement Time-History Data, Plus Load-Interaction Time-History Data (if NLIC $\neq$ 0), being written to the user's data file, in data set DSC, Defined in JCL.
NBAL	If MSC/NASTRAN is To Be Used For a Static Solution, Then NBAL is The Mass Number That is Constrained to Have Zero Deflections and Rotations.
ICD	Parameter Which Determines Whether an Additional Data Set of Mass and Node Point Static Deflections is To Be Read Following the Basic Input Data Set. ICD = 0 Means That The Additional Data Set is Not Read. Any Nonzero Input Causes The Program to Read The Initial Deflection Data.
ICITER	Parameter Which Determines Whether The Initial Mass and Node Point Deflection Data (ICD $\neq$ 0) is Used To Modify The Input Airplane Coordinates For The Mass and Node Points. ICITER = 0 Means The Initial Static Deflection Data is Not Used to Modify The Mass Coordinates; i.e., The Airplane is Left in Its Undeformed Position. Any Nonzero Value of ICITER Results in The Input Mass Coordinates Being Modified to Reflect The Initial Static Deflections, i.e., The Airplane Assumes The Deformed Shape Corresponding to The Initial Static Load Condition.

REMARKS:

- (1) Required data card; however, it may be blank.
- (2) All entries are right justified integers.
- (3) See Section 3.1 for a discussion of the load-interaction curve data; Section 2.1 for a discussion of initial conditions.
- (4) Format for this card is 6I5.

KRASH INPUT DATA

CARD 0070: ACCELERATION TRANSFER CONTROL PARAMETERS

DESCRIPTION: Defines number of time-history tables of mass accelerations to be used.

FORMAT AND EXAMPLE:

0	1	2	3	4	5	6	7	8
1	2	3	4	5	6	7	8	9
(CSIN)	X	(RNIN)	X	NTAB				
			3					0070

FIELD

CONTENTS

(CSIN) Not Used

(RNIN) Not Used

NTAB Number of Acceleration Time-History Tables to Be Used From Previous Run. Using Data Set Identified as DSA in JCL. Maximum Allowed is 100.

REMARKS:

- (1) Required data card; however, it may be blank.
- (2) NTAB is input as a right justified integer.
- (3) See Section 3.2 for a discussion of acceleration transfer procedures.
- (4) Format for this card is (A6, 4X, A10, 5X, 15).

KRASH INPUT DATA

CARD 0080: ACCELERATION TRANSFER CONTROL PARAMETERS

DESCRIPTION: Defines data for saving mass and mode point accelerations for later use as input data in another run.

FORMAT AND EXAMPLE:

0	1	2	3	4	5	6	7	8
1	2	3	4	5	6	7	8	9
(CSOUT)	X	(RNOUT)	NMSAV	NNPSAV	NDTSAV	NWRFLG	NDTGRA	
			6	3	10	1	20	0080

FIELD CONTENTS

(CSOUT) Not Used
(RNOUT) Not Used
NMSAV Number of Masses For Which Selected Acceleration Data Will be Saved in Data Set DSB (Identified in JCL), as Specified on 500-Series Cards (Maximum allowed is 80) See Remark (5).
NNPSAV Number of Node Points For Which Selected Acceleration Data Will be Saved in Data Set DSB (Identified in JCL), as Specified on 600-Series Cards (Maximum Allowed is 50) See Remark (5)
NDTSAV Multiple of Integration Time Interval DT at Which Acceleration Data Will be Saved. See Remark (4)
NWRFLG Parameter Governing Whether Selected Acceleration Data Will be written to User's Data File as Data Set DSB. Any Nonzero Value Will Cause The Data to be Written: NWRFLG = 0 Will Cause The Data Not to be Written. Regardless of The Remaining Input Parameters on This Card.
NDTGRA Multiple of Integration Time Interval DT at Which Mass and Node Point Displacement Data Will be Written to User's Data File as Data Set DSC (Identified in JCL). This Data is Used For Graphics Postprocessing. NWRGRA on Card 0600 Must be Nonzero For This Data to be Written as DSC in User's Data File. NDTGRA Also Defines The Time Interval For Saving Load-Interaction Data. For The Load Interaction Data, if NWRGRA on Card 0060 is Zero, The Print Output Will Still Contain Time-Histories of All Load Interaction Output Data. If it is Desired to Save This Data in Data Set DSC For Postprocessing, Then NWRGRA Must be Input Nonzero. See Remark (4).

REMARKS:

- (1) Required data card; however, it may be blank.
- (2) All entries are right justified integers.
- (3) See Sections 3.1 and 3.2 for discussions of load-interaction curve data and acceleration transfer control and graphics data.
- (4) Both NDTSAV and NDTGRA must be chosen so that less than 100 time cuts are saved for each response quantity. This is satisfied if

$$\left(\begin{matrix} \text{NDTSAV} \\ \text{and} \\ \text{NDTGRA} \end{matrix} \right) > \frac{\text{TMAX}}{100 * \text{DT}}$$

- (5) The total number of response quantities saved (total number of nonzero MFL's and NPFL's on 0500 and 0600 Series Cards) must be less than 100.
- (6) Format for this card is (A6, 4X, A10, 5110).

KRASH INPUT DATA

CARD 0090: RESTART CONTROL PARAMETERS

DESCRIPTION: Defines the identifiers of a previously checkpointed KRASH case and the simulation time from which the KRASH analysis will be restarted.

FORMAT AND EXAMPLE:

0	1	2	3	4	5	6	7	8
12345678901	2345678901	2345678901	2345678901	2345678901	2345678901	2345678901	2345678901	2345678901
CASEIN	X	RUNIN	MSECIN					X
OLEO		1	40					0090

FIELD

CONTENTS

CASEIN

Alphanumeric Identifier of Checkpointed Case (Maximum of Eight Characters, Left Justified)

RUNIN

Numeric Identifier of Checkpointed Case

MSECIN

Restart Time – Milliseconds

REMARKS:

- (1) Required data card, however, it may be blank.
- (2) All numeric entries are right justified integers.
- (3) Previously checkpointed case must be resident on mag tape and be accessed via JCL.
- (4) Restart time must be included in the KRASH analysis of the previously checkpointed case.
- (5) Only nonblank when using restart capability to initiate from a preceding analysis that has been saved.
- (6) Format for this card is(A8, 2X, 6I10).

KRASH INPUT DATA

CARD 0100: CHECKPOINT CONTROL PARAMETERS

DESCRIPTION: Defines identifiers and simulation times for the current KRASH case to checkpoint the analytical results for future restarts.

FORMAT AND EXAMPLE:

0	1	2	3	4	5	6	7	8
1	2	3	4	5	6	7	8	9
CASEOUT	X	RUNOUT	MSCOUT(1)	MSCOUT(2)	MSCOUT(3)	MSCOUT(4)	MSCOUT(5)	X
OLEO		2	40	80	100	120	150	0100

<u>FIELD</u>	<u>CONTENTS</u>
--------------	-----------------

CASEOUT	Alphanumeric Identifier (Maximum of Eight Characters, Left Justified)
---------	---

RUNOUT	Numeric Identifier
--------	--------------------

MSCOUT1	Analysis Times at Which Results Will be Saved – Milliseconds
---------	--

REMARKS:

- (1) Required data card; however, it may be blank.
- (2) All numeric entries are right justified integers.
- (3) JCL must provide mag tape on which results will be saved.
- (4) Only nonblank when data are to be saved. A maximum of five times can be saved per analysis.
- (5) Format for this card is (A8, 2X, 6I10.0).

KRASH INPUT DATA

CARD 0110: **PARAMETERS FOR NUMERICAL INTEGRATION, PLOWING FORCE, ACCELERATION FILTER, AND KRASH EXECUTION MODE**

DESCRIPTION: Defines print control, numerical integration time step, analysis time, plowing force time, acceleration filter cutoff frequency, and KRASH execution mode (airplane model and impact condition symmetry).

FORMAT AND EXAMPLE:

0	1	2	3	4	5	6	7	8
12345678901	2345678901	2345678901	2345678901	2345678901	2345678901	2345678901	2345678901	234567890
DP/DT	DT	TMAX	PLOWT	FCUT	RUNMOD			
100	0.00001	0.120	0.0	100.0	1.0			0110

FIELD

CONTENTS

DP/DT Multiple of Numerical Integration Time Interval at Which Output Will be Printed.
Right Justified Interger

DT Fixed Time Step For Numerical Integration – Seconds

TMAX Maximum Analysis Time – Seconds

PLOWT Analysis Time at Which Plowing Forces Cease – Seconds

FCUT Cutoff Frequency of First-Order Filter Applied to Mass Point Translational Accelerations –
Hertz (E10.0 Format)

RUNMOD Flag to Control the Mode of Program Execution as Follows:

RUNMOD	INPUT DATA SET	DATA SET ANALYZED	AIRPLANE MODEL	IMPACT CONDITIONS
0.	Full Airplane	Full Airplane	Unsymmetrical	Unsymmetrical
1.	Half Airplane	Half Airplane	Symmetrical	Symmetrical
2.*	Half Airplane	Full Airplane	Symmetrical	Unsymmetrical

*See remark (5)

REMARKS:

- (1) Required data card.
- (2) 'DP/DT', 'DT', 'TMAX', and 'RUNMOD' are required inputs.
- (3) Blank entries are read as zero.
- (4) Entries requiring scientific notation (X.XEXX) should be right justified.
- (5) For RUNMOD = 2, image mass number = 100 + mass number.
- (6) Suitable values for 'DT' range from 0.00001 to 0.001 seconds. A rule of thumb for selecting a final integration value is the following:
DT ≤ 0.01 Max. Computed Beam Frequency (Hz).
- (7) Nonzero plowing forces act from time = 0 to time = 'PLOWT'. For time > 'PLOWT' the plowing forces are set to zero.
- (8) Suitable values for 'FCUT' range from fifty to eighty-five percent of the actual test filter cutoff frequency. Eighty-five percent is commonly used.
- (9) Format for this card is (I10, 5E10.0).

KRASH INPUT DATA

CARD 0120: VARIABLE INTEGRATION PARAMETERS

DESCRIPTION: Define parameters for numerical integration with variable time step.

FORMAT AND EXAMPLE:

0	1	2	3	4	5	6	7	8
1	2	3	4	5	6	7	8	9
IVAR	EL	EU	RATMIN	RATMAX				
1	0.01	0.10	0.6	2.0				0120

FIELD CONTENTS

IVAR Flag For Type of Numerical Integration With Variable Time Step as Follows (Right Justified Integer):

IVAR	TYPE OF NUMERICAL INTEGRATION WITH VARIABLE TIME STEP
0	None
1	Tolerance Based on Six Linear and Angular Velocities of Each Mass Point
2	Tolerance Based on Energy

FL Maximum Tolerance
 EU Minimum Tolerance
 RATMIN Integration Time Step Factor if Tolerance > 'EU'
 RATMAX Integration Time Step Factor if Tolerance < 'EU'

REMARKS: (1) Required data card, but it should be blank as the variable integration algorithm is not currently operational.
 (2) Blank entries are read as zero.
 (3) Format for this card is (I10,4E10.0).

KRASH INPUT DATA

CARD 0130: PRINT OUTPUT CONTROL

DESCRIPTION: Defines flags to control the printout of results, KRASH model size parameters, and allowable errors in energy for terminating the analysis.

FORMAT AND EXAMPLE:

[illegible]

<u>FIELD</u>	<u>CONTENTS</u>
NSF	Flag For Printout of Beam Element Strain Forces
NTF	Flag For Printout of Beam Element Total Forces – Strain and Damping
NDE	Flag For Printout of Beam Element Deflections
NSPD	Flag For Printout of External Crushing Spring Loads and Deflections
NED	Flag For Printout of Energy Distribution Per Mass Point, Beam Element, and External Crushing Spring
NS	Flag For Printout of Beam Element Stresses
NRP	Flag For Printout of Mass Point Displacement, Velocity, and Accelerations
NIMP	Flag For Printout of Mass Impulses
NBC	Flag For Printout of Beam Component Loads

REMARKS:

- (1) Required data card; however, it may be blank.
- (2) All entries are right justified integers.
- (3) Blank entries are read as zero.
- (4) Print control flags: 0 = No, 1 = Yes.
- (5) At time zero or the first time cut of a restart, all print will be output regardless of the entries on this card.
- (6) Format for this card is 8I5.

KRASH INPUT DATA

CARD 0140: PRINTER PLOT CONTROL PARAMETERS

DESCRIPTION: Defines the type and number of time history printer plots and defines the number of mass point position (structure deformation) printer plots.

FORMAT AND EXAMPLE:

0 1 2 3 4 5 6 - 8													
1234567890123456789012345678901234567890123456789012345678901234567890													
NMEP	NNEP	NBFP	NBDP	NSTP	NSEP	NENP	NDRP	NPLT	NPFCT				
21	0	3	0	0	0	2	1	2	20				0140

<u>FIELD</u>	<u>CONTENTS</u>
NMEP	Number of Mass Points Having Time History Printer Plots Per 3900-Series Cards
NNEP	Number of Massless Node Points Having Time History Printer Plots Per 4000-Series Cards
NBFP	Number of Beam Elements Having Load Time History Printer Plots Per 4100-Series Cards
NBDP	Number of Beam Elements Having Deflection Time History Printer Plots Per 4200-Series Cards
NSTP	Number of Beam Elements Having Stress Time History Printer Plots Per 4300-Series Cards
NSEP	Number of External Crushing Springs Having Time History Printer Plots Per 4400-Series Cards
NENP	Number of Beam Elements Having Strain and/or Damping Energy Time History Printer Plots Per 4500-Series Cards
NDRP	Number of DRI Mass Points Having Time History Printer Plots Per 4600-Series Cards
NPLT	Number of Mass Point Position (Structure Deformation) Printer Plots Per 3700/3800-Series Cards
NPFACT	Print Time Factor For Which Mass Point Position (Structure Deformation) Plots Are Generated

REMARKS:

- (1) Required data card; however, it may be blank.
- (2) All entries are right justified integers.
- (3) Blank entries are read as zero.
- (4) Blank or zero entries do not generate printer plots.
- (5) Mass position plots occur at time = 0, and at intervals equal to $NPFCT \times DP \times DT \times DT$.
- (6) Format for this card is 10I5.

KRASH INPUT DATA

CARD 0150: INITIAL AIRPLANE LINEAR VELOCITIES

DESCRIPTION: Defines the initial airplane linear velocity components with respect to the ground coordinate system.

FORMAT AND EXAMPLE:

0	1	2	3	4	5	6	7	8
1	2	3	4	5	6	7	8	9
0	1	2	3	4	5	6	7	8
1	2	3	4	5	6	7	8	9
XGDOT	YGDOT	ZGDOT						
0.0	0.0	360.0						0150

FIELD

CONTENTS

XGDOT Initial Fore-and-Aft Velocity of Airplane, Positive Forward
 YGDOT Initial Lateral Velocity of Airplane, Positive Right
 ZGDOT Initial Vertical Velocity of Airplane, Positive Down

REMARKS:

- (1) Required data cards; however, it may be blank.
- (2) Velocity units are inches per second.
- (3) Blank entries are read as zero.
- (4) Entries requiring scientific notation (X.XEXX) should be right justified.
- (5) Format for this card is 3E10.0.

KRASH INPUT DATA

CARD 0160: INITIAL AIRPLANE ANGULAR VELOCITIES

DESCRIPTION: Defines the initial airplane angular velocity components with respect to the ground coordinate system.

FORMAT AND EXAMPLE:

0	1	2	3	4	5	6	7	8
12345678901	23456789012	34567890123	45678901234	56789012345	67890123456	78901234567	89012345678	90123456789
PPR	QPR	RPR						
0.0	0.0	0.012						0160

FIELD	CONTENTS
-------	----------

PPR	Initial Airplane Roll Velocity, Positive Right Wing Down
QPR	Initial Airplane Pitch Velocity, Positive Nose Up
RPR	Initial Airplane Yaw Velocity, Positive Nose Right

REMARKS:

- (1) Required data card; however, it may be blank.
- (2) Angular velocity units are radians per second.
- (3) Blank entries are read as zero.
- (4) Entries requiring scientific notation (X.XEXX) should be right justified.
- (5) Format for this card is 3E10.0.

KRASH INPUT DATA

CARD 0170. MISCELLANEOUS AIRPLANE INITIAL CONDITIONS

DESCRIPTION: Defines the initial airplane attitude Euler angles and the initial airplane linear position with respect to the ground coordinate system and defines the ground plane slope angle.

FORMAT AND EXAMPLE:

0	1	2	3	4	5	6	7	8
1	2	3	4	5	6	7	8	9
PHIPR	THEPR	PSIPR	XGIN	ZGIN	BETA	RHO		
0.0	0.001	0.0	0.0	0.0	45.0	1.1463E-07		0170

FIELD

CONTENTS

PHIPR Initial Airplane Roll Euler Angle, Positive Right Wind Down – Radians
 THEPR Initial Airplane Pitch Euler Angle, Positive Nose Up – Radians
 PSIPR Initial Airplane Yaw Euler Angle, Positive Nose Right – Radians
 XGIN Fore-and-Aft Distance of Airplane Initial CG Position Relative to the Basic Position
 Calculated in the Initial Condition Subroutine, Positive Aft – Inches
 ZGIN Vertical Distance of Airplane Initial CG Position Relative to the Basic Position
 Calculated in the Initial Condition Subroutine, Positive Up – Inches
 BETA Ground Plane Slope Angle, Positive Up – Degrees
 RHO Air Density Used for Calculating Aerodynamic Loads (NAERO #0). Pound-Sec²/In⁴

REMARKS:

- (1) Required data card; however, it may be blank.
- (2) Blank entries are read as zero.
- (3) Normally, 'XGIN' and 'ZGIN' are input as zero and the KRASH initial conditions subroutine positions the airplane relative to ground.
- (4) If it is desired to have the airplane impact only on the slope and not on the horizontal ground, a large value of ZGIN may be input (1000 inches). This will move the airplane upward ZGIN above the horizontal ground, and simultaneously move it forward so that it is almost contacting the slope. The normal initial position for the airplane is wedged into the juncture of the horizontal ground and the slope as explained in Volume I, Section 1.3.1⁵
- (5) Values of 'BETA' range from zero to ninety degrees (horizontal to vertical impact surfaces).
- (6) Entries requiring scientific notation (X.XE^{XX}) should be right justified.
- (7) If NSP = 0 (no external springs), ZGIN is the distance from the ground plane to the airplane CG, positive up.
- (8) Formats for this card is 7E10.0.

KRASH INPUT DATA

CARDS 0200: MASS POINT DATA

DESCRIPTION: Defines the weight, location coordinates, and mass moments of inertia for each of the mass points in the KRASH model.

FORMAT AND EXAMPLE:

0		1		2		3		4		5		6		7		8	
123456789012345678901234567890123456789012345678901234567890123456789012345678901234567890																	
WGT		XDP		YDP		ZDP		XI		YI		ZI		ID			
103.0		50 0		20.0		33.0		12.5		3.7		12.5		21		0200	

FIELD	CONTENTS
-------	----------

WGT	Weight – Pounds
XDP	Fuselage Station Coordinate, Positive Aft – Inches
YDP	Buttline Coordinate, Positive Left – Inches
ZDP	Waterline Coordinate, Positive Up – Inches
XI	Roll Mass Moment of Inertia – Inch * Pound * Second**2
YI	Pitch Mass Moment of Inertia – Inch * Pound * Second**2
ZI	Yaw Mass Moment of Inertia – Inch * Pound * Second**2
ID	Mass Point Number

REMARKS:

- (1) 'NM' on card 0040 specifies the number of these cards for input.
- (2) The order of these cards determines the mass point number.
- (3) Blank entries are read as zero.
- (4) The location coordinates are defined in a left-handed coordinate system.
- (5) At least one of the three mass moments of inertia must be nonzero.
- (6) Mass moment of inertia cross products may be defined on the 3100-series of cards.
- (7) Entries requiring scientific notation (X.XE^{XX}) should be right justified.
- (8) Mass point number (ID) must be greater than zero or less than 100. Mass numbers must be unique and can be input in any order. If ID for any mass point is left blank, all mass points will automatically be numbered sequentially in the order of input.
- (9) For RUNMOD = 2, the Image mass point number will equal the mass point number plus 100.
- (10) Formats for this card is 7E10.0, I2.

KRASH INPUT DATA

CARDS 0300: **MASSLESS NODE POINT DATA**

DESCRIPTION: Defines for each of the massless node points in the **KRASH** model the location coordinates and the mass point number to which each is rigidly attached.

FORMAT AND EXAMPLE:

0									
1		2		3		4		5	
6		7		8					
1	2	3	4	5	6	7	8	9	0
MNP	INP	XNPDP	YNPDP	ZNPDP					
1	12	10.0	- 12.0	33.0					0300

FIELD CONTENTS

MNP Massless Node Point Number (Right Justified Integer)
 INP Mass Point Number (Right Justified Integer)
 XNPDP Fuselage Station Coordinate, Positive Aft -- Inches
 YNPDP Buttline Coordinate, Positive Left -- Inches
 ZNPDP Waterline Coordinate, Positive Up -- Inches

- REMARKS:
- (1) Optional data card(s).
 - (2) 'NMP' on card 0040 specifies the number of these cards for input.
 - (3) 'MNP' and 'INP' must be nonzero.
 - (4) Blank entries are read as zero.
 - (5) The massless node point number is determined by taking each mass point and numbering the node points attached to it 1, 2, 3, . . . etc. There is no limit on the number of node points that may be connected to a single mass point.
 - (6) The location coordinates are defined in a left-handed coordinate system.
 - (7) User should not place a node point on the center line for a RUNMOD = 2 condition. Program will not generate a connection across this point. User can place node point slightly off center, if necessary.
 - (8) Generally used to model regions wherein rigid connections exist (i.e., seat, engine) or where multiple behavior is being represented by different elements.
 - (9) Entries requiring scientific notation (X.XEXX) must be right justified.
 - (10) Format for this card is (2I5, 3E10.0).

KRASH INPUT DATA

CARDS 0400: ACCELERATION TRANSFER DATA

DESCRIPTION: Defines the correspondence between mass/node point numbers from a previous model for which acceleration data was saved, and the current model which is to use the acceleration data as input forcing functions.

FORMAT AND EXAMPLE:

0	1	2	3	4	5	6	7	8
1	2	3	4	5	6	7	8	9
ISNEW	(MSNEW)	LSNEW	ISOLD	MSOLD	LSOLD	TSH		
3		4	6	3	4	.003		0400

FIELD	CONTENTS
ISNEW	Mass Number in Current (New) Model That Will be Driven by an Acceleration Table Saved in Data Set DSA (defined in JCL)
(MSNEW)	Not Used (Coding Does Not Allow Driving a Node Point With an Input Acceleration)
LSNEW	Direction for Which Table Read From Data Set DSA Will Drive Mass ISNEW LSNEW: 1 = XACCEL 4 = PDOT 2 = YACCEL 5 = QDOT 3 = ZACCEL 6 = RDOT
ISOLD	Mass Number in Previous (OLD) Model, The Acceleration From Which Will be Used to Drive Mass ISNEW in The Current Model
MSOLD	Node Point Number in Previous (OLD) Model. Coding Allows Driving a Mass in The Current Model With an Acceleration From a Node Point in The Previous Model
LSOLD	Direction of Acceleration Saved in Prior Model to be Used to Drive the Current Model. It is Not Necessary for LSOLD = LSNEW; i.e., an XACCEL From a Previous Model Can Drive a ZACCEL in The Current Model LSOLD: 1 = XACCEL 4 = PDOT 7 = XACC FILTERED 2 = YACCEL 5 = QDOT 8 = YACC FILTERED 3 = ZACCEL 6 = RDOT 9 = ZACC FILTERED
TSH	Time Shift Applied to Data From Previous Model (Stored in DSA) Before Using in Current Model. This Allows User to Apply a "Downstream" Response From Previous Model as Input to The Current Model, Which Starts at t = 0

$$t_{NEW} = t_{OLD} - TSH$$

- REMARKS:**
- (1) Optional data card(s).
 - (2) NTAB on card 0070 specifies the number of these cards for input.
 - (3) Data set DSA, generated from a previous run, must be in the user's data file in order to use the acceleration transfer data. The actual data set name for DSA is specified in the JCL.
 - (4) A different TSH can be specified for each table used.
 - (5) Filtered accelerations from a previous model can be used to drive the current model. (LSOLD = 7, 8 or 9).
 - (6) Format for this card is (6I5, 1E10.0).

KRASH INPUT DATA

CARDS 0500: MASS ACCELERATION SAVE PARAMETERS

DESCRIPTION: Defines mass numbers and directions for saving acceleration time-history data.

FORMAT AND EXAMPLE:

	0	1	2	3	4	5	6	7	8		
	1	2	3	4	5	6	7	8	9	0	1
X	ISAV	MFL1	MFL2	MFL3	MFL4	MFL5	MFL6	MFL7	MFL8	MFL9	
	15	0	0	1	0	1	1	0	1	0	0500

<u>FIELD</u>	<u>CONTENTS</u>
ISAV	Mass Number For Which Acceleration Data From Current Run Will be Stored in User's Data File in Data Set DSB
MFL1 - MFL9	Flags Defining For Which Directions (1-9) Acceleration Data is to be Saved in Data Set DSB. Input Either 1 or 0 for Each Item; 1 Denotes Save The Acceleration Time-History For The Indicated Direction. Directions 1-9 Correspond to The Description of LSOLD on Cards 0400.

REMARKS:

- (1) Optional data card(s).
- (2) NMSAV on Card 0080 specifies the number of these cards for input.
- (3) Date set DSB is specified in the JCL.
- (4) The acceleration data is saved at time intervals of NDTSAV, specified on Card 80.
- (5) NWRFLG on Card 80 must be nonzero to write the acceleration data into date set DSB.
- (6) Format for this card is (5X, 10I5).

KRASH INPUT DATA

CARDS 0600: NODE POINT ACCELERATION SAVE PARAMETERS

DESCRIPTION: Defines node point numbers and directions for saving acceleration time-history data.

FORMAT AND EXAMPLE:

0		1		2		3		4		5		6		7		8
1		2		3		4		5		6		7		8		9
MNPSAV	INPSAV	NPFL1	NPFL2	NPFL3	NPFL4	NPFL5	NPFL6	NPFL7	NPFL8	NPFL9						
3	15	0	0	1	0	1	1	0	1	0						0600

FIELD CONTENTS

ISAV Mass and Node Point Number for Which Acceleration Data From Current Run Will be
 MNPSAV Stored in User's Data File in Data Set DSB
 NPFL1 Flags Defining for Which Directions (1-9) Acceleration Data is to be Saved in Data Set DSB.
 NPFL9 Input Either 1 or 0 for Each Item; 1 Denotes Save The Acceleration Time-History for The
 Indicated Direction. Directions 1-9 Correspond to The Description of LSOLD on Cards 0400.

REMARKS: (1) Optional data card(s).
 (2) NNPSAV on Card 0080 specifies the number of these cards for input.
 (3) Date set DSB is specified in the JCL.
 (4) The acceleration data are saved at time intervals of NDTSAV, specified on Card 80.
 (5) NWRFLG on Card 80 must be nonzero to write the acceleration data into date set DSB.
 (6) Format for this card is 1115.

KRASH INPUT DATA

CARDS 0700: EXTERNAL CRUSHING SPRING PARAMETERS

DESCRIPTION: Defines the attach point, direction, length, ground coefficient of friction, bottoming spring rate, plowing force, and ground flexibility for each of the external crushing springs in the KRASH model.

FORMAT AND EXAMPLE:

0		1		2		3		4		5		6		7		8	
12345678901		2345678901		2345678901		2345678901		2345678901		2345678901		2345678901		2345678901		2345678901	
M	I	K	XLBAR	XMU	XKE	FPLOW	GFLEX	ITIRE									
	11	3	10.0	0.3	20000.0	0.0	0.0	1									0700

<u>FIELD</u>	<u>CONTENTS</u>
M	Massless Node Point Number (Right Justified Integer)
I	Mass Point Number (Right Justified Integer)
K	Degree-of-Freedom in Which External Crushing Spring Acts Where 1, 2, 3 Correspond to the X, Y, Z Directions in the Mass Point Coordinate System (Right Justified Integer)
XLBAR	Free Length of Spring Either Positive or Negative in the Mass Point Coordinate System - Inches
XMU	Impact Surface Coefficient of Friction. Values of Between 0.35 to 0.60 are Appropriate For Structure to Ground Contact.
XKE	Bottoming Spring Rate -- Pounds Per Inch
FPLOW	Plowing Force -- Pounds
GFLEX	Impact Surface Flexibility -- Inches Per Pound
ITIRE	Defines spring that remains normal to contact surface
<u>REMARKS:</u>	(1) Optional data card(s). (2) 'NSP' on card 0040 specifies the number of these cards for input. (3) Blank entries are read as zero. (4) The free length of the external crushing spring is arbitrary; however, the value generally represents the actual depth of the crushable structure. (5) A value of zero for the impact surface flexibility (GFLEX) represents a rigid surface. A flexibility value of 0.00036 in/lb is an approximate representation in KRASH for soil, having a CBR ≈ 4 and moisture content of ≈ 30 percent. (6) Entries requiring scientific notation (X.XEXX) must be right justified. (7) If ITIRE = 1 external spring remains normal to contact surface. Use only for tire representation in K = 3 direction. If Beta > 0 tire spring remains normal to sloped surface. Not coded to account for transition from flat to sloped surface. (8) Format for this card is (I2, I3, I5, 5E10.0, I5).

KRASH INPUT DATA

CARDS 0800: EXTERNAL CRUSHING SPRING LOAD-DEFLECTION AND DAMPING PARAMETERS

DESCRIPTION: Defines four deflection points, two load values and one damping value for each external crushing spring in the KRASH model.

FORMAT AND EXAMPLE:

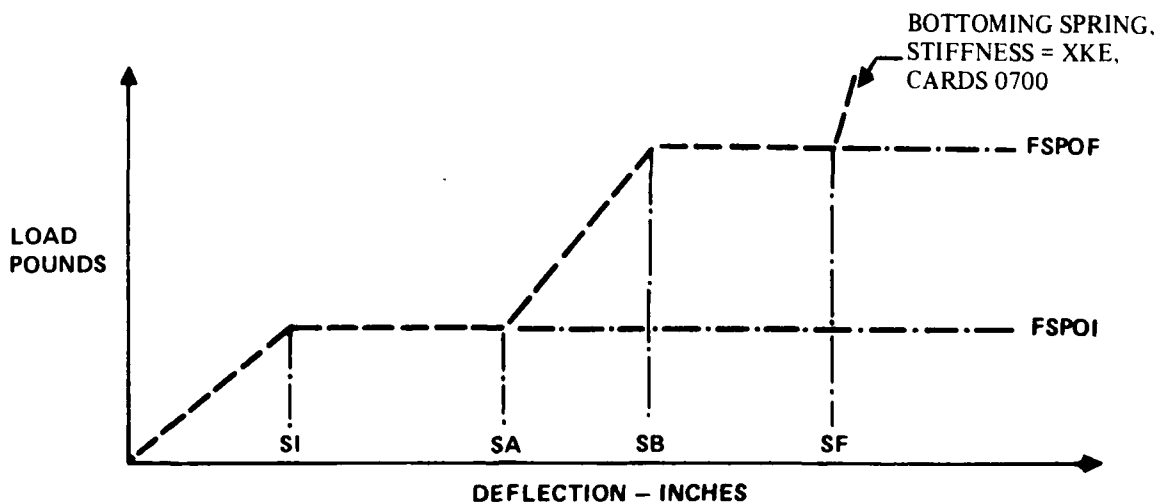
0	1	2	3	4	5	6	7	8
12345678901	2345678901	2345678901	2345678901	2345678901	2345678901	2345678901	2345678901	2345678901
SI	SA	SB	SF	FSPOI	FSPDF	CDAMP	X	
0.1	1.0	3.5	5.0	10000.0	25000.0	.08		0800

FIELD **CONTENTS**

SI Deflection Point at Which First Linear Region Ends and First Nonlinear Region Begins – Inches
SA Deflection Point at Which First Nonlinear Region Ends and Second Linear Region Begins – Inches
SB Deflection Point at Which Second Linear Region Ends and Second Nonlinear Region Begins – Inches
SF Deflection Point at Which Second Nonlinear Region Ends and Linear Bottoming Begins – Inches
FSPOI Constant Load Between Deflection Points SI and SA – Pounds
FSPOF Constant Load Between Deflection Points SB and SF – Pounds
CDAMP Critical Damping Ratio. Acceptable Range is .02 to .10

REMARKS:

- (1) 'NSP' on card 0040 specifies the number of these cards for input.
- (2) These load-deflection cards must be ordered to correspond with the 0700-series cards of external crushing spring data.
- (3) The general shape of the load-deflection curve is as follows:



KRASH INPUT DATA

CARDS 0800: EXTERNAL CRUSHING SPRING LOAD-DEFLECTION AND DAMPING PARAMETERS
(Continued)

- (4) External spring damping in program KRASH is computed as:

$$2 * CDAMP * \sqrt{(FSPOI/SI) * WGT / 386.4}$$

where WGT is the weight for mass i.

- (5) Entries requiring scientific notation (X.XEXX) should be right justified.
(6) Format for this card is 7E10.0.

KRASH INPUT DATA

CARDS 0900: BEAM ELEMENT PROPERTIES

DESCRIPTION: Defines the end points and cross-sectional properties for each beam element in the KRASH model.

FORMAT AND EXAMPLE:

0		1		2		3		4		5		6		7		8
1		2		3		4		5		6		7		8		9
M	I	N	J	AA		XJ		IYY		IZZ		XIQ		Z1	Z2	MC
	2	1	5	0.5		0.0		3.67		1.54		0.0		0.0	0.0	4 900

FIELD

CONTENTS

M	Massless Node Point Number At End "I" (Right Justified Integer)
I	Mass Point Number At End "I" (Right Justified Integer)
N	Massless Node Point Number at End "J" (Right Justified Integer)
J	Mass Point Number At End "J" (Right Justified Integer)
AA	Cross-Sectional Area -- Inches**2.
XJ	Torsional Stiffness Inertia -- Inches**4
IYY	Cross-Sectional Area Moment of Inertia About Beam Element Y-Axis For Bending In X-Z Plane -- Inches**4
IZZ	Cross-Sectional Area Moment Of Inertia About Beam Element Z-Axis For Bending In X-Y Plane -- Inches**4
XIQ	Cross-Sectional Shape Factor Relating Torsional Shear Stress To The Applied Moment -- 1/Inches**3
Z1	Distance From The Neutral Axis To The Extreme Fibers In The Beam Element Z-Direction -- Inches
Z2	Distance From The Neutral Axis To The Extreme Fibers In The Beam Element Y-Direction -- Inches
MC	Material Code Number (Right Justified Integer)

REMARKS:

- (1) "NB" on card 0040 specifies the number of these cards for input.
- (2) Blank entries are read as zero.
- (3) At least one beam element must be defined.
- (4) The order of these data cards determines the beam element number.
- (5) If "XJ" is input as zero, KRASH will automatically compute a value for "XJ" as the sum of "IYY" and "IZZ".
- (6) The beam element coordinate system depends on the geometric orientation as shown in Figure 2-5.
- (7) "XIQ", "Z1", and "Z2" are used only for stress calculations (See Section 1.3.17 in Volume I).
- (8) The torsional stress parameter "XIQ" is equal to the shape factor "I/Q" used in Roark's formulas for stress and strain (Reference 4).
- (9) KRASH has ten standard materials internally defined as shown in Table 2-2.
- (10) Entries requiring scientific notation (X.XEXX) should be right justified.
- (11) Format for this card is (2(I2, I3), 5E10.0, 2F5.0, I2).

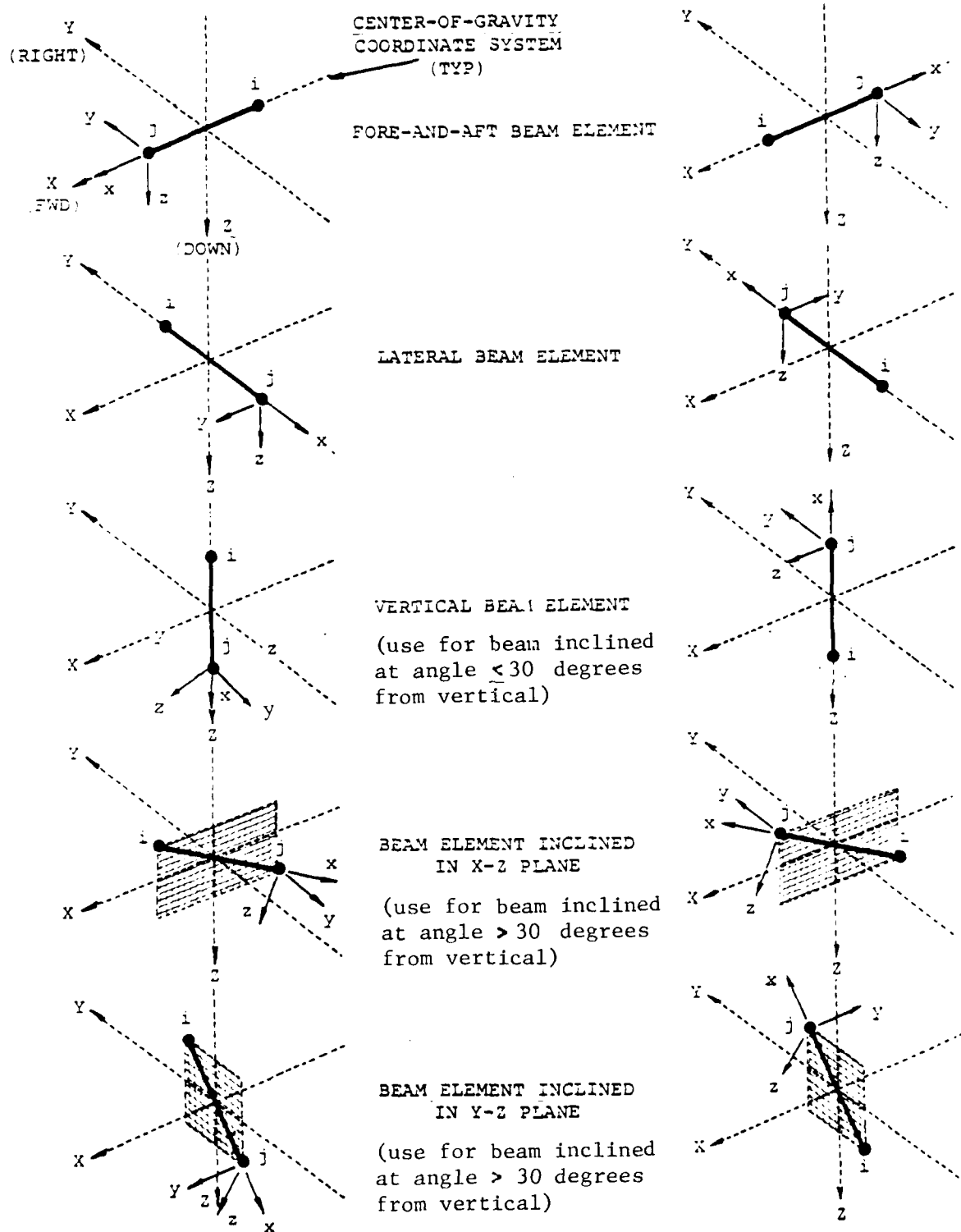


FIGURE 2-5. BEAM ELEMENT COORDINATE SYSTEM ORIENTATIONS

TABLE 2-3. STANDARD MATERIAL PROPERTIES

MC	MATERIAL	MODULUS OF ELASTICITY (PSI)	MODULUS OF RIGIDITY (PSI)	TENSILE STRESS (PSI)	COMPRESSIVE STRESS (PSI)	SHEAR STRESS (PSI)
1	4130 STEEL	30.0E6	11.0E6	75000	75000	37500
2	6150H STEEL	30.0E6	11.0E6	205000	205000	80000
3	300-SERIES STAINLESS STEEL	28.0E6	12.5E6	70000	46000	36000
4	2024 T3 ALUMINUM	10.5E6	4.0E6	47000	39000	22000
5	6061-T3 ALUMINUM	10.0E6	3.8E6	35000	34000	17000
6	8195-T4 CAST ALUMINUM	10.0E6	3.8E6	16000	16000	17000
7	LOW MODULUS MATERIAL	1.0E6	0.4E6	16000	16000	17000
8	ZERO TORSION MATERIAL	1.0E6	0.0	16000	16000	17000
9	DRI SPINE (MAN)	1.0E6	0.4E6	16000	16000	17000
10	DRI SPINE (DRI)	1.0E6	0.4E6	16000	16000	17000

KRASH INPUT DATA

CARDS 1000: NON-STANDARD MATERIAL PROPERTIES

DESCRIPTION: Defines non-standard material properties for beam elements in the KRASH model.

FORMAT AND EXAMPLE.

0	1		2		3		4		5		6		7		8				
1	2	3	4	5	6	7	8	9	0	1	2	3	4	5	6	7	8	9	0
MC			EE			GG			STENS			SCOMP			SHEAR				
11			10.3E06			3.9E06			35000.0			34000.0			17000.0				1000

<u>FIELD</u>	<u>CONTENTS</u>
MC	Material Code Number, MC = 11-20 (Right Justified Integer)
EE	Modulus Of Elasticity – Pounds Per Inch**2
GG	Modulus Of Rigidity – Pounds Per Inch**2
STENS	Tensile Yield Stress – Pounds Per Inch**2
SCUMP	Compressive Yield Stress – Pounds Per Inch**2
SHEAR	Shear Stress – Pounds Per Inch**2

REMARKS

- (1) Optional data card(s).
- (2) "NMTL" on card 0040 specifies the number of these cards for input.
- (3) Blank entries are read as zero.
- (4) The yield stress properties are required when stress calculations are desired.
- (5) The standard materials available in KRASH are listed in Table 2-2.
- (6) Entries requiring scientific notation (X.XE^{XX}) should be right justified.
- (7) Format for this card is (15, 5X, 5E10.0).

KRASH INPUT DATA

CARDS 1100: BEAM ELEMENT PINNED END CONDITIONS

DESCRIPTION: Defines the end points and the degrees-of-freedom for the beam elements with pinned end conditions in the KRASH model.

FORMAT AND EXAMPLE:

0		1		2		3		4		5		6		7		8			
1	2	3	4	5	6	7	8	9	0	1	2	3	4	5	6	7	8	9	0
M	I	N	J	PYI	PZI	PYJ	PZJ	SF35	SF26	SF35J	SF26J	X							
	2	6	0	0	1	0	1.0	1.5	1.2		1.0								1100

FIELD

CONTENTS

M	Massless Node Point Number At End "I"
I	Mass Point Number At End "I"
N	Massless Node Point Number At End "J"
J	Mass Point Number At End "J"
PYI	Pin Flag For Bending Moment About Beam Element Y-Axis At End "I"
PZI	Pin Flag For Bending Moment About Beam Element Z-Axis At End "I"
PYJ	Pin Flag For Bending Moment About Beam Element Y-Axis At End "J"
PZJ	Pin Flag For Bending Moment About Beam Element Z-Axis At End "J"
SF35	Beam Shape Factor At End "I" About Beam Y-Axis
SF26	Beam Shape Factor At End "I", About Beam Z-Axis
SF35J	Beam Shape Factor At End "J" About Beam Y-Axis
SF26J	Beam Shape Factor At End "J" About Beam Z-Axis

REMARKS:

- (1) Optional data card(s).
- (2) "NPIN" on card 0040 specifies the number of these cards for input.
- (3) The pin flags are defined as follows:
0 = Fixed
1 = Pinned
- (4) Blank entries are read as zero.
- (5) All entries except SF26, SF35, SF26J and SF35J are right justified integers.
SF26, SF35, SF26J and SF35J are E10.0 format.
- (6) The beam element Y- and Z-axis directions depend on the beam element geometric orientation as shown in Figure 2-3.
- (7) Bending moments about the beam element Y- and Z-axes correspond to bending moments in the beam element X-Z and X-Y planes, respectively, as outlined in Table 2-3.
- (8) All entries requiring scientific notation (X.XEXX) should be right justified.
- (9) Format for this card is (2 (I2, I3), 4I5, 4E10.0).
- (10) Beam shape factors SF26 and SF35, SF26J, and SF35J can be obtained from Table 2-4. and Reference 14.
- (11) SF26, and/or SF35 values are required for representation of plastic hinge at beam end I.
- (12) SF26J and/or SF35J values are required for representation of plastic hinge at beam end J.

NOTE:

The end fixity card is used:

(a) to pin one or both ends of a beam

If a beam end is to be pinned then the desired PY, PZ, PYJ and PZJ flags are used and the SF26, SF35, SF26J and SF35J values are input as zero. The program will treat these beams as not providing for moments at the appropriate end and direction.

(b) to define a beam that can develop a plastic hinge at one or both ends of the beam.

If a plastic hinge is represented the appropriate beam end direction (PY, PZ, PYJ, PZJ) must be flagged and a corresponding (SF35, SF26, SF35J, SF26J) must have a value. The program will treat such a beam as fixed until such time as the plastic moment is formed. Thereafter the beam moment in the noted direction is maintained (no longer changes). In order to use the plastic moment equations the user must have beam section properties Z1 or Z2 (card 0900) defined since KRASH computes the plastic moment as follows:

$$M_p = f \left(\frac{\sigma_y I}{y_{\max}} \right)$$

where

f = shape factor (SF35, SF26, SF35J, SF26J)

σ_y = material yield stress (contained in the material code table), lb/in²

I = area moment of inertia, either I_{yy} or I_{zz} , in⁴

$y_{\max}$ = distance to neutral axis either Z1 or Z2, in

The following table shows the relationship between directional moments and appropriate input terms for program KRASH.

TABLE 2-4. RELATIONSHIP FOR DIRECTIONAL MOMENTS AND INPUT TERMS IN KRASH

FORCE ALONG AXIS	MOMENT ABOUT AXIS	FORCE, MOMENT DESIGNATION	KRASH DIRECTION NUMBERS	APPROPRIATE INPUT REQUIREMENT					
				AREA MOMENT OF INERTIA (CARD 0900)	DISTANCE FROM N.A. TO ELEMENT EXTREME FIBER (CARD 0900)	SHAPE FACTOR		PIN CODING	
						"i" END	"j" END	"i" END	"j" END
z	y	I_z, M_θ	3, 5	IYY	Z1	SF35	SF35J	PY	PYJ
y	z	I_y, M_ψ	2, 6	IZZ	Z2	SF26	SF26J	PZ	PZJ

TABLE 2-5. SHAPE FACTORS FOR PLASTIC HINGE BEAMS (Reference 14)

SHAPE	SHAPE FACTOR, f (SF35, SF26, SF35J, SF26J) IN PROGRAM KRASH
	2.37
	2.0
	1.7
	1.5
	1.40 $t/d = 10$ 1.27 $t = 0$
	1.15 Ranges 1.10 to 1.22
0 $f = Z/S$ $Z = 2 H_e$ $S = I/Y_{max}$ where: I = Section area moment of inertia Y_{max} = Distance from neutral axis to extreme fiber H_e = Static moment of half the cross section with respect to the neutral axis Z = Plastic modulus S = Elastic section modulus f = Shape factor	

KRASH INPUT DATA

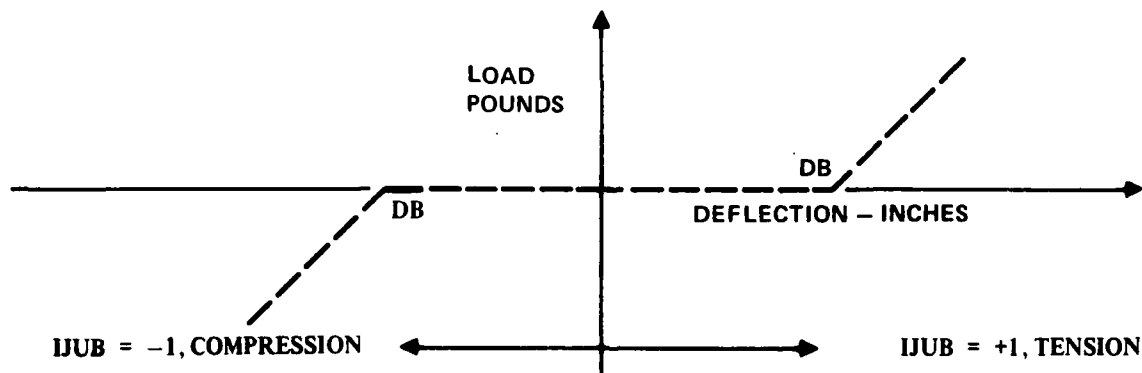
CARDS 1200: AXIALLY UNSYMETRIC BEAM ELEMENT PARAMETERS

DESCRIPTION: Defines end points, type of load, and deadband for the beam elements with unsymmetrical axial properties in the KRASH model.

FORMAT AND EXAMPLE:

[illegible]

<u>FIELD</u>	<u>CONTENTS</u>
M	Massless Node Point Number At End "I" (Right Justified Integer)
I	Mass Point Number At End "I" (Right Justified Integer)
N	Massless Node Point Number At End "J" (Right Justified Integer)
J	Mass Point Number At End "J" (Right Justified Integer)
IJUB	Flag For The Type Of Axial Loading In The Beam Elements IJUB = +1. Tension Only IJUB = -1. Compression Only
DB	Deadband for axial loading, inches
<u>REMARKS</u>	(1) Optional data card(s). (2) "NUB" on card 0040 specifies the number of these cards for input. (3) Blank entries are read as zero. (4) The general form of the load-deflection curve for the axially unsymmetric beam element is as follows:



- (5) This type of beam element may also incorporate nonlinear characteristics by specifying the nonlinear properties per the 1800-series cards.
- (6) The axial load-deflection curves that can be obtained using this capability are described in Volume I, Section 1.3.5.3.5. (Reference 1)
- (7) Format for this card is (2 (12, 13), 15, 5X, E 10.0).

KRASH INPUT DATA

CARD 1290: SHOCK STRUT DATA

DESCRIPTION: Friction coefficient and number of metering pin tables.

FORMAT EXAMPLE:

0	1	2	3	4	5	6	7	8
12345678901	2345678901	2345678901	2345678901	2345678901	2345678901	2345678901	2345678901	2345678901
ALPHAP	NMPTAB							
1.0	2							1290

<u>FIELD</u>	<u>CONTENTS</u>
ALPHAP	Constant For Use In Computing Shock Strut Friction Force
NMPTAB	Number of Separate Metering Pin Tables Input on Cards 1490/1500.

REMARKS:

- (1) Optional data card.
- (2) Required only if NOLEO $\neq 0$ (card 0040)
- (3) Only 1 card regardless of NOLEO value
- (4) Blank entry read as zero
- (5) Range of ALPHAP is between .1 to 2.0. The smaller the alphap used the closer the representation is to pure Coulomb friction. Generally a value of 1.0 is suitable.
- (6) See Appendix A for the discussion on oleo friction forces for alphap selection.
- (7) Format for this card is (E10.0, I10).

KRASH INPUT DATA

CARDS 1300: SHOCK STRUT DATA

DESCRIPTION: Air curve parameters

FORMAT EXAMPLE:

0										1										2										3										4										5										6										7										8									
12345678901										2345678901										2345678901										2345678901										2345678901										2345678901										2345678901										2345678901										2345678901									
M	I	N	J	EOLEO										FAO										FAA										EXPOLE										YMAX																																													
	1		7	10.27										116.										5.										1.0										9.32																														1300															

FIELD

CONTENTS

M	Massless Node Point Number In End "I" (Right Justified Integer)
I	Mass Point Number At End "I" (Right Justified Integer)
N	Massless Node Point Number At End "J" (Right Justified Integer)
J	Mass Point Number At End "J" (Right Justified Integer)
EOLEO	Effective Total Strut Cylinder Length, in.
FAO	Fully Extended Gear Preload, lb.
FAA	Ambient Air Preload, lb.
EXPOLE	Polytropic Exponent.
YMAX	Maximum Stroke, in.

REMARKS:

- (1) Optional data cards.
- (2) "NOLEO" on card 0040 specifies the number of these cards for input.
- (3) All entries requiring scientific notation (X.XEXX) should be right justified.
- (4) EXPOLE ranges from 1 (isothermal) to 1.4 (adiabatic). Adiabatic condition will usually prevail.
- (5) See Appendix A for a description of the shock strut parameters and their usage.
- (6) Format for this card is (2 (I2, I3), 5E10.0).

KRASH INPUT DATA

CARDS 1400: SHOCK STRUT DATA

DESCRIPTION: Damping constants, linear springs at extended and compressed ends of strut travel and coulomb friction.

FORMAT EXAMPLE:

0		1		2		3		4		5		6		7		8	
12345678901		2345678901		2345678901		2345678901		2345678901		2345678901		2345678901		2345678901		2345678901	
M	I	N	J	BOLEO		BROLEO		XKEXT		XKCOMP		FCOUL		MPTAB		X	
	1		7	0.24		0.48		10000.		10000.		5.5		1		1400	

FIELD

CONTENTS

M Massless Node Point Number At End "I" (Right Justified Integer)
I Mass Point Number At End "I" (Right Justified Integer)
N Massless Node Point Number At End "J" (Right Justified Integer)
J Mass Point Number At End "J" (Right Justified Integer)
BOLEO Strut Orifice Damping lb-sec²/in²
BROLEO Strut Rebound Valve Damping lb-sec²/in²
XKEXT Linear Spring At Extended End Of Strut Travel, lb/in.
XKCOMP Linear Spring At Compressed End Of Strut Travel, lb/in.
FCOUL Coulomb Or Constant Friction Force, lbs.
MPTAB Metering Pin Table Number. If a Metering Pin Is Not Used, Input Zero. MPTAB
Refers to Metering Pin Tables Input Sequentially On 1500-Series Cards.

REMARKS:

- (1) Optional data cards.
- (2) "NOLEO" on card 0040 specifies the number of these cards for input.
- (3) All entries requiring scientific notation (X.XEXX) should be right justified.
- (4) See Appendix A for a description of the shock strut parameters and their usage.
- (5) If a metering pin table is used, BOLEO is ignored. If MPTAB is input as a negative integer, the subsequent table on cards 1500 is interpreted as total gear load versus stroke. This is used only for the inverse metering pin option, explained in Appendix A.
- (6) No. of cards = NPTSMP value (card 1290)
- (7) Format for this card is (2 (I2, I3), 5E10.0, I10).

KRASH INPUT DATA

CARD 1490: METERING PIN DATA

DESCRIPTION: Number of points in following metering pin table

FORMAT EXAMPLE:

0	1	2	3	4	5	6	7	8
1	2	3	4	5	6	7	8	9
NPTSMP								
15								1490

FIELD

CONTENTS

NPTSMP Number of Cards in The Following Table of YOLEO Versus BOLEO (Maximum Allowable is 100)

REMARKS:

- (1) Optional data card. Required only if MPTAB is nonzero on any of the 1400-Series cards.
- (2) This card precedes each 1500-Series of metering pin table cards. For example, if there were 3 metering pin tables (NMPTAB = 3 on card 1290), the proper sequence would be

1490	1 card
1500-XX	NPTSMP ₁ cards
1490	1 card
1500-XX	NPTSMP ₂ cards
1490	1 card
1500-XX	NPTSMP ₃ cards

(3) Format for this card is 110

KRASH INPUT DATA

CARDS 1500: METERING PIN DATA

DESCRIPTION: Table(s) of oleo piston compression versus damping constant.

FORMAT EXAMPLE

0	1	2	3	4	5	6	7	8
1	2	3	4	5	6	7	8	9
YOLEO	BOLEO							
7.	1.76E02							1500

FIELD	CONTENTS
-------	----------

YOLEO	Oleo Piston Compression, Inches, Measured From Fully Extended Position
BOLEO	Oleo Hydraulic Damping Constant, Pound-Sec ² /in ² , at The Piston Position Defined by YOLEO

REMARKS	
(1)	Optional data card(s). NPTSMF on card 1490 defines the number of these cards to input. If NMPTAB= 0 on card 1290, then none of these cards are used.
(2)	Format for this card is 2E10.0.
(3)	If MPTAB on card 1400 is input as a negative integer, then BOLEO on the corresponding 1500-Series cards is interpreted as total gear load. This is referred to as the inverse metering pin option, which can be used to calculate BOLEO versus YOLEO if a known (or desired) load-deflection characteristic curve is input on this series of cards. This option is explained in Appendix A.

KRASH INPUT DATA

CARD 1600: **BEAM ELEMENT DAMPING RATIO**

DESCRIPTION: Defines an overall damping ratio for the beam elements in the KRASH model.

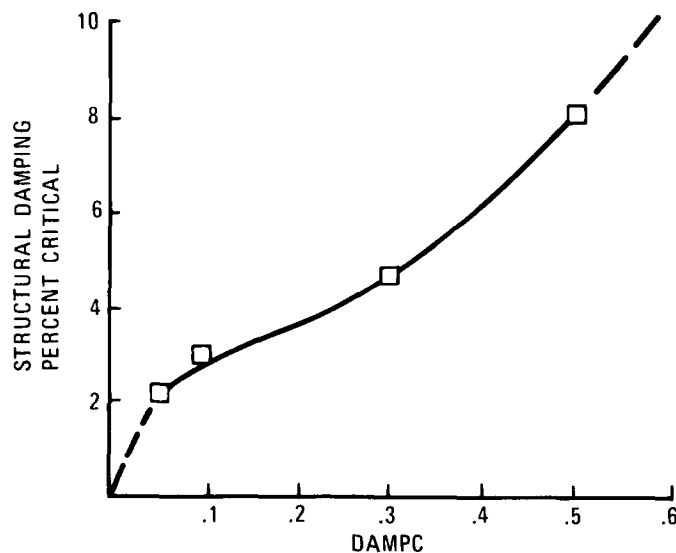
FORMAT AND EXAMPLE

0	1	2	3	4	5	6	7	8
1234567890	1234567890	1234567890	1234567890	1234567890	1234567890	1234567890	1234567890	1234567890
DAMPC								
0.10								1600

FIELD CONTENTS

DAMPC Damping Ratio (Actual/Critical)

- REMARKS:
- (1) Required data card; however, it may be blank.
 - (2) Blank entry is read as zero damping for all beams.
 - (3) DAMPC values in KRASH are between .1 and .5. The sketch below shows the relationship between DAMPC values and percent of critical damping.
 - (4) Format for this card is E10.0



KRASH INPUT DATA

CARDS 1700: NON-STANDARD BEAM ELEMENT DAMPING RATIOS

DESCRIPTION: Defines the end points and damping ratio for each beam element in the KRASH model for which a non-standard damping ratio is required.

FORMAT AND EXAMPLE:

0		1		2		3		4		5		6		7		8	
1		2		3		4		5		6		7		8		9	
M	I	N	J	CBAR													
	2	1	5	0.10												1700	

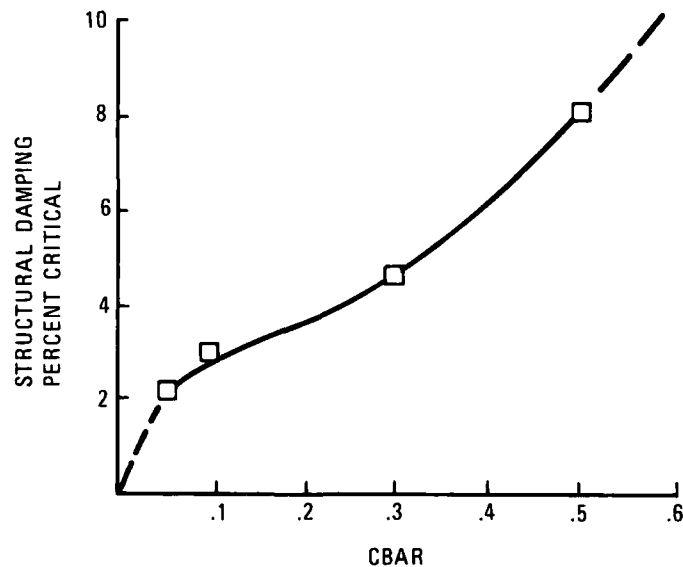
FIELD

CONTENTS

M Massless Node Point Number At End "I" (Right Justified Integer)
 I Mass Point Number At End "I" (Right Justified Integer)
 N Massless Node Point Number At End "J" (Right Justified Integer)
 J Mass Point Number At End "J" (Right Justified Integer)
 CBAR Damping Ratio (Actual/Critical)

REMARKS:

- (1) Optional data card(s).
- (2) "ND" on card 0040 specifies the number of these cards for input.
- (3) Blank entries are read as zero.
- (4) CBAR values in KRASH are between .1 and .5. The sketch below shows the relationship between CBAR values and percent critical damping.
- (5) Format for this card is (2 (12, 13), E10.0).



KRASH INPUT DATA

CARDS 1800: NONLINEAR BEAM ELEMENT PARAMETERS

DESCRIPTION: Defines the end points, degree-of-freedom, KR table type, and linear deflection points for the nonlinear beam elements in the KRASH model.

FORMAT AND EXAMPLE:

0		1		2		3		4		5		6		7		8		
1	2	3	4	5	6	7	8	9	0	1	2	3	4	5	6	7	8	9
M	I	N	J	L	NP	LDP	LDP1											
	2	1	5	3	7	1.5	0.0									1800		

FIELD

CONTENTS

M Massless Node Point Number At End "1" (Right Justified Integer)
 I Mass Point Number At End "I" (Right Justified Integer)
 N Massless Node Point Number At End "J" (Right Justified Integer)
 J Mass Point Number At End "J" (Right Justified Integer)
 L Nonlinear Degree-Of-Freedom Where L = 1, 2, 3, 4, 5, 6 Corresponds To The Beam Element Coordinate System Directions X, Y, Z, ϕ , θ , ψ . Respectively (Right Justified Integer)
 NP Number Of Data Points Used In KR Table (Right Justified Integer)
 LDP Deflection At Which Nonlinear Behavior Begins - Inches
 LDP1 Deflection At Which Nonlinear Behavior Ends And Linear Restiffening Begins - Inches except as noted in remark (8).

REMARKS:

- (1) Optional data card(s).
- (2) "NLB" on card 0040 specifies the number of these cards for input.
- (3) Blank entries are read as zero.
- (4) The nonlinear degrees-of-freedom are specified in the beam element coordinate systems shown in figure 2-3.
- (5) For "NP" = 4-9 the corresponding standard KR tables are shown in figure 2.6. For "NP" >9 the user will input a nonstandard KR table with "NP" data points.
- (6) "LDP1" is used for the KR table "NP" = 9 and for "NP" = 4 (see remark 8).
- (7) The theory on how the KR curves are used to calculate internal beam loads is shown in Volume I, Section 1.3.5.3.4. (Reference 1).
- (8) For "NP" = 4 the LDP value represents the deflection value at which KR = 1. (LINEAR). LDP1 represents KR value (< 1). $0 \leq \text{deflection} \leq \text{LDP}$. NP = 4 can be useful for modeling elements such as a seat cushion which is soft initially and stiffens during compression. Do not use with LDP1 > 1.0
- (9) Format for this card is (2 (I2, I3) 2I5, 2E10.0).

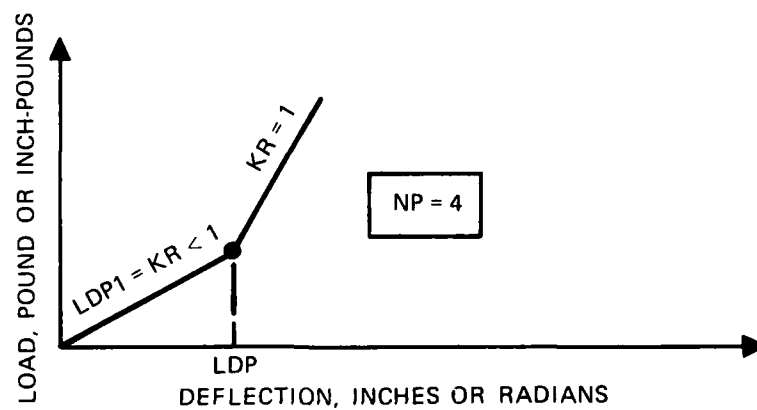
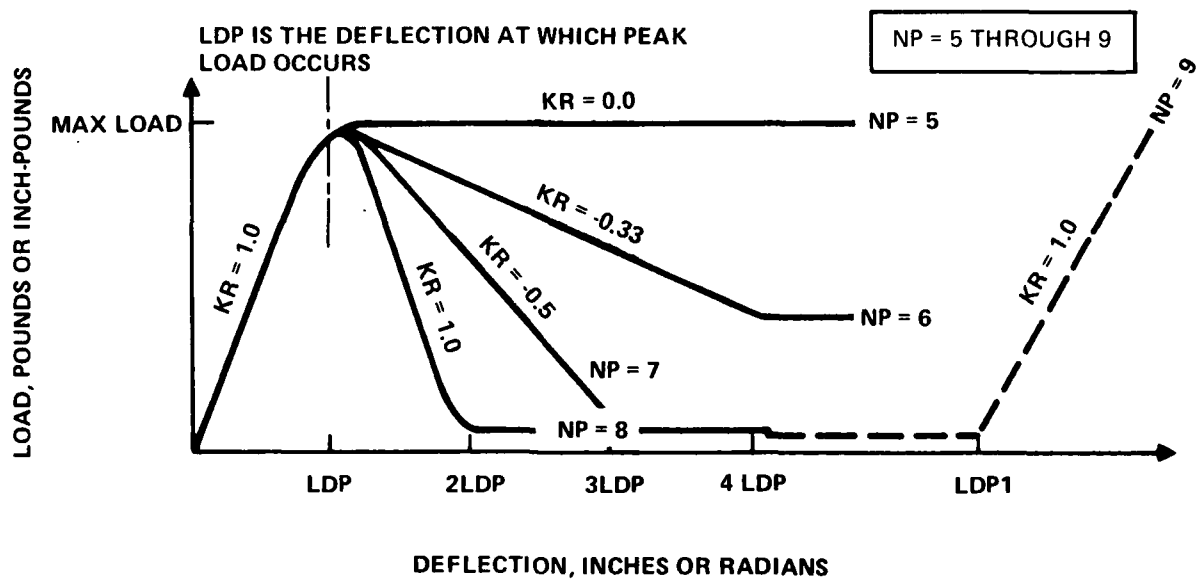


FIGURE 2-6. STANDARD NONLINEAR BEAM ELEMENT STIFFNESS REDUCTION CURVES

KRASH INPUT DATA

CARDS 1900: NON-STANDARD KR TABLE DATA POINTS

DESCRIPTION: Defines non-standard KR tables for the nonlinear beam elements in the KRASH model which cannot be described with the standard KR tables.

FORMAT AND EXAMPLE:

0	1	2	3	4	5	6	7	8
12345678901	2345678901	2345678901	2345678901	2345678901	2345678901	2345678901	2345678901	234567890
XKR	KR							
1.0	-1.0							1900.

FIELD

CONTENTS

XKR Deflection - Inches
KR Stiffness Reduction Factor at XKR

REMARKS:

- (1) Optional data cards.
- (2) For each use of "NP" > 9 on the 1200-series cards, "NP" of these cards are required input.
- (3) Blank entries are read as zero.
- (4) Within each set of "NP" data cards, deflections must be in ascending order.
- (5) Each set of "NP" data cards must be ordered to correspond with the 1800 - series cards where "NP" > 9 is used.
- (6) Format for this card is 2E10.0.

KRASH INPUT DATA

CARD 2000: CONTROL VOLUME MASS PENETRATION PARAMETERS

DESCRIPTION: Defines a control volume around a selected mass point in the KRASH model which is monitored for penetration by another mass point during the analysis.

FORMAT AND EXAMPLE:

0	1	2	3	4	5	6	7	8
1234567890	1234567890	1234567890	1234567890	1234567890	1234567890	1234567890	1234567890	1234567890
XN	XP	YN	YP	ZN	ZP			
10.0	10.0	3.0	4.0	10.5	2.9			2000

<u>FIELD</u>	<u>CONTENTS</u>
XN	Distance From Mass Point To Aft Side Of Control Volume
XP	Distance From Mass Point To Forward Side Of Control Volume
YN	Distance From Mass Point To Left Side Of Control Volume
YP	Distance From Mass Point To Right Side Of Control Volume
ZN	Distance From Mass Point To Top Side Of Control Volume
ZP	Distance From Mass Point To Bottom Side Of Control Volume

- REMARKS:
- (1) Optional data card.
 - (2) 'MVP' on card 0040 specifies the mass point number for which this data card applies.
 - (3) Only one mass point may have a control volume.
 - (4) Blank entries are read as zero.
 - (5) All distances are positive and units are inches.
 - (6) For a RUNMOD = 2 the MVP mass should be selected from a mass point located on the airplane centerline. This restriction doesn't apply to RUNMOD = 0 or 1.
 - (7) Any of the model mass points may penetrate the designated control volume of the model.
 - (8) The mass penetration calculations are described in Volume I, Section 1.3.10.
 - (9) Format for this card is 6E10.0.

KRASH INPUT DATA

CARD 2100: DRI ELEMENT SPECIFICATION

DESCRIPTION: Defines the end mass points of the DRI beam elements in the KRASH model.

FORMAT AND EXAMPLE:

0		1		2		3		4		5		6		7		8			
1	2	3	4	5	6	7	8	9	0	1	2	3	4	5	6	7	8	9	0
I1	J1	I2	J2	I3	J3	I4	J4	I5	J5	I6	J6	I7	J7	X					
3	10																		2100

FIELD

CONTENTS

II

Mass Point Number At End "I"

J1

Mass Point Number At End "J"

REMARKS:

- (1) Optional data card(s).
- (2) "NDRI" on card 0040 specifies the number of these cards for input.
- (3) All entries are right justified integers.
- (4) Blank entries are read as zero.
- (5) Up to seven DRI beam elements can be specified on each card. (Normally an analysis requires from 1 to 4 DRI elements).
- (6) DRI beam element section properties can be defined on the 0900-series cards or if a MTL code of 10 is used the program will automatically compute the DRI properties.
- (7) Beams that connect massless node points cannot be used as DRI elements, only direct mass to mass connection is allowed.
- (8) The usage of DRI elements is described in Volume I, Section 1.3.12.
- (9) Format for this card is 14I5.

KRASH INPUT DATA

CARD 2200: OCCUPIABLE VOLUME CHANGE PARAMETERS

DESCRIPTION: Defines occupiable volumes in the KRASH model for volume change calculations by specifying the eight corner mass points.

FORMAT AND EXAMPLE:

0		1		2		3		4		5		6		7		8			
1	2	3	4	5	6	7	8	9	0	1	2	3	4	5	6	7	8	9	0
I1	I2	I3	I4	I5	I6	I7	I8												
3	7	12	13	21	23	31	35												2200

FIELD

CONTENTS

I1	Mass Point Number At Forward End, Upper Left-Hand Corner
I2	Mass Point Number At Forward End, Upper Right-Hand Corner
I3	Mass Point Number At Aft End, Upper Left-Hand Corner
I4	Mass Point Number At Aft End, Upper Right-Hand Corner
I5	Mass Point Number At Forward End, Lower Left-Hand Corner
I6	Mass Point Number At Forward End, Lower Right-Hand Corner
I7	Mass Point Number At Aft End, Lower Left-Hand Corner
I8	Mass Point Number At Aft End, Lower Right-Hand Corner

REMARKS:

- (1) Optional data card(s).
- (2) "NVCH" on card 0004 specifies the number of these cards for input.
- (3) All entries are right justified integers.
- (4) Blank entries are not allowed.
- (5) The volume change calculations are explained in Volume I, Section 1.3.11 (Figure 1-16).
- (6) For a symmetrical full model (RUNMOD = 2 type) when only half the data is input the user inputs mass point locations 1, 3, 5, 7 (I1, I3, I5, I7). The opposite side mass point locations 2, 4, 6, 8 (I2, I4, I6, I8) are input as zero (blank). KRASH automatically computes the opposite side masses. See Volume I, Figure 1-16 for mass point designations.
- (7) Format for this card is 8I5.

KRASH INPUT DATA

CARDS 2300: NON-STANDARD MAXIMUM BEAM ELEMENT POSITIVE DEFLECTIONS
FOR RUPTURE

DESCRIPTION: Defines the end points and the maximum positive deflections and rotations for
rupture of beam elements in the KRASH model.

FORMAT AND EXAMPLE:

0		1		2		3		4		5		6		7		8	
1	2	3	4	5	6	7	8	9	0	1	2	3	4	5	6	7	8
M	I	N	J	VMAX1		VMAX2		VMAX3		VMAX4		VMAX5		VMAX6		X	
	2	1	6	10.0		15.2		100.0		100.0		0.2					2300

FIELD

CONTENTS

M Massless Node Point Number At End "I" (Right Justified Integer)
I Mass Point Number At End "I" (Right Justified Integer)
N Massless Node Point Number At End "J" (Right Justified Integer)
J Mass Point Number At End "J" (Right Justified Integer)
VMAX1 Maximum Deflection In Beam Element X-Direction - Inches
VMAX2 Maximum Deflection In Beam Element Y-Direction - Inches
VMAX3 Maximum Deflection In Beam Element Z-Direction - Inches
VMAX4 Maximum Rotation About Beam Element X-Axis - Radians
VMAX5 Maximum Rotation About Beam Element Y-Axis - Radians
VMAX6 Maximum Rotation About Beam Element Z-Axis - Radians

REMARKS:

- (1) Optional data card(s).
- (2) "NVBM" on card 0050 specifies the number of these cards for input.
- (3) The standard or default values for maximum deflections and rotations are 100 inches and 100 radians, respectively. The deflections and rotations refer to relative motions of the j end of the beam minus the i end of the beam.
- (4) The beam element coordinate systems are shown in Figure 2-5.
- (5) All values are input as positive numbers.
- (6) Format for this card is (2 (I2, I3), 6E10.0).

KRASH INPUT DATA

CARDS 2400:

NON-STANDARD MAXIMUM BEAM ELEMENT NEGATIVE DEFLECTIONS FOR RUPTURE

DESCRIPTION: Defines the end points and the maximum negative deflections and rotations for rupture of beam elements in the KRASH model.

FORMAT AND EXAMPLE:

0		1		2		3		4		5		6		7		8			
1	2	3	4	5	6	7	8	9	0	1	2	3	4	5	6	7	8	9	0
M	I	N	J	VMAXN1	VMAXN2	VMAXN3	VMAXN4	VMAXN5	VMAXN6										
	2	1	6	10.0	15.2	100.0	100.0	0.2	100.0										2400

FIELD

CONTENTS

M	Massless Node Point Number At End "I" (Right Justified Integer)
I	Mass Point Number At End "I" (Right Justified Integer)
N	Massless Node Point Number At End "J" (Right Justified Integer)
J	Mass Point Number At End "J" (Right Justified Integer)
VMAXN1	Maximum Deflection In Beam Element X-Direction - Inches
VMAXN2	Maximum Deflection In Beam Element Y-Direction - Inches
VMAXN3	Maximum Deflection In Beam Element Z-Direction - Inches
VMAXN4	Maximum Rotation About Beam Element X-Axis - Radians
VMAXN5	Maximum Rotation About Beam Element Y-Axis - Radians
VMAXN6	Maximum Rotation About Beam Element Z-Axis - Radians

REMARKS:

- (1) Optional data card(s).
- (2) "NVBMN" on card 0050 specifies the number of these cards for input.
- (3) The standard or default values for maximum deflections and rotations are 100 inches and 100 radians, respectively. The deflections and rotations refer to relative motions of the j end of the beam minus the i end of the beam.
- (4) The beam element coordinate systems are shown in Figure 2-5.
- (5) All values are input as positive numbers.
- (6) Format for this card is (2 (I2, I3), 6E10.0).

KRASH INPUT DATA

CARDS 2500: NONSTANDARD MAXIMUM BEAM ELEMENT POSITIVE LOADS FOR RUPTURE

DESCRIPTION: Defines the end points and the maximum forces and moments for rupture of beam elements in the KRASH model.

FORMAT AND EXAMPLE:

0		1		2		3		4		5		6		7		8	
12345678901		2345678901		2345678901		2345678901		2345678901		2345678901		2345678901		2345678901		2345678901	
M	I	N	J	FMAX1		FMAX2		FMAX3		FMAX4		FMAX5		FMAX6		X	
	3		7	10.0E10		1000.0		10.0E10		10.0E10		10.0E6		10.0E10			2500

FIELD CONTENTS

M Massless Node Point Number at End "I" (Right Justified Integer)
I Mass Point Number at End "1" (Right Justified Integer)
N Massless Node Point Number at End "J" (Right Justified Integer)
J Mass point Number at End "J" (Right Justified Integer)
FMAX1 Maximum Axial Force in Beam Element X-Direction - Pounds
FMAX2 Maximum Shear Force in Beam Element Y-Direction - pounds
FMAX3 Maximum Shear Force in Beam Element Z-Direction - Pounds
FMAX4 Maximum Torque About Beam Element X-Axis - Inch * Pounds
FMAX5 Maximum Bending Moment About Beam Element Y-Axis - Inch * Pounds
FMAX 6 Maximum Bending Moment About Beam Element Z-Axis - Inch * Pounds

REMARKS:

- (1) Optional data card(s).
- (2) "NFBM" on card 0050 specifies the number of these cards for input.
- (3) The standard of default values for maximum rupture forces and moments are 1.E10 pounds and inch-pounds, respectively.
- (4) Entries requiring scientific notation (X.XEXX) should be right justified.
- (5) Blank entries are read as zero.
- (6) The beam element coordinate systems are shown in Figure 2-5.
- (7) All values are input as positive numbers.
- (8) The input values are compared to the time-varying beam loads at the j end of the beam to determine if beam rupture occurs.
- (9) Format for this card is (2(I2, I3), 6E10.0).

KRASH INPUT DATA

CARDS 2600:

NON-STANDARD MAXIMUM BEAM ELEMENT NEGATIVE LOADS FOR RUPTURE

DESCRIPTION: Defines the end points and the maximum forces and moments for rupture of beam elements in the KRASH model.

FORMAT AND EXAMPLE:

0				1				2				3				4				5				6				7				8						
1	2	3	4	5	6	7	8	9	0	1	2	3	4	5	6	7	8	9	0	1	2	3	4	5	6	7	8	9	0	1	2	3	4	5	6	7	8	9
M	I	N	J	FMAXN1				FMAXN2				FMAXN3				FMAXN4				FMAXN5				FMAXN6				X										
	3		7	10.0E10				1000.0				10.0E10				10.0E10				10.0E6				10.0E10					2600									

FIELD

CONTENTS

M Massless Node Point Number at End 'I' (Right Justified Integer)
I Mass Point Number at End 'I' (Right Justified Integer)
N Massless Node Point Number at End 'J' (Right Justified Integer)
J Mass Point Number at End 'J' (Right Justified Integer)
FMAXN1 Maximum Axial Force In Beam Element X-Direction – Pounds
FMAXN2 Maximum Shear Force In Beam Element Y-Direction – Pounds
FMAXN3 Maximum Shear Force In Beam Element Z-Direction – Pounds
FMAXN4 Maximum Torque About Beam Element X-Axis – Inch * Pounds
FMAXN5 Maximum Bending Moment About Beam Element Y-Axis – Inch * Pounds
FMAXN6 Maximum Bending Moment About Beam Element Z-Axis – Inch * Pounds

REMARKS:

- (1) Optional data card(s).
- (2) 'NFBMN' on card 0050 specifies the number of these cards for input.
- (3) The standard or default values for maximum rupture forces and moments are 1.E10 pounds and inch-pounds, respectively.
- (4) Entries requiring scientific notation (X.XEXX) should be right justified.
- (5) Blank entries are read as zero.
- (6) The beam element coordinate systems are shown in Figure 2-5.
- (7) All values are input as positive numbers.
- (8) The input values are compared to the time-varying beam loads at the j end of the beam to determine if beam rupture occurs.
- (9) Format for this card is (2(I2, I3), 6E10.0).

KRASH INPUT DATA

CARDS 2700: LOAD INTERACTION CURVE SIGN CONVENTION DATA

DESCRIPTION: Defines the sign conventions to be used for load-interaction data output.

FORMAT AND EXAMPLE:

0	1	2	3	4	5	6	7	8
1234567890	1234567890	1234567890	1234567890	1234567890	1234567890	1234567890	1234567890	1234567890
ISCV1	ISCV2	ISCV3	ISCV4	ISCV5	ISCV6			
3	-2	5	6	-4	1			2700

<u>FIELD:</u>	<u>CONTENTS</u>
---------------	-----------------

ISCV1-
ISCV6

CALAC (Lockheed-California Co.) sign convention load number to be used for the corresponding user defined loads. The above example results in the following correspondence between the user-defined loads and the CALAC sign convention loads:

User Loads	1	2	3	4	5	6	are made up of
CALAC Loads	3	-2	5	6	-4	1	

REMARKS:

- (1) Optional data card(s).
- (2) NSCV on card 0060 defines the number of these cards for input.
- (3) Any nonzero ISCN on the 2800-series cards requires a corresponding sign convention definition card in the 2700 series.
- (4) Section 3.1 describes the load-interaction data and the significance of the user-defined sign conventions.
- (5) The format for this card is 615

KRASH INPUT DATA

CARDS 2800: LOAD INTERACTION CURVE DATA

DESCRIPTION: Defines the beams to be analyzed for load-interaction curves, the two interacting load directions, sign conventions to be applied, exact location along the beams and rupture ratio.

FORMAT AND EXAMPLE:

0		1		2		3		4		5		6		7		8	
12345678901		2345678901		2345678901		2345678901		2345678901		2345678901		2345678901		2345678901		2345678901	
IJ	K	L	NLIL	ISCN	NSMI	FSLIC		BLLIC		WLLIC		RUPRAT					
7	3	5	3	1	10	1160.						1.4					2800

FIELD CONTENTS

IJ Beam number, the internal loads from which are to be analyzed on load-interaction diagrams.

K,L Load directions for the x and y axes of load-interaction curve. In the above example, 3,5 means use Fz and My, in the user-defined sign convention.

NLIL Number of sloping load-interaction lines, the data for which is defined on the 3000-series cards. The maximum allowed per load-interaction diagram is 20, including those lines generated as mirror images.

ISCN User-defined sign convention number to be applied to the beam internal loads before selecting the K,L loads for this load interaction diagram. If ISCN = 0, then the CALAC internal load sign convention, defined in Section 4.15 reference 1, is used.

NSMI *Number of masses involved if shear and moment summation of a particular station is required.*

FSLIC, Defines the location on the airplane for this load-interaction curve. Input only one of these
BLLIC, nonzero. For fore-aft beams, use FSLIC. For lateral beams use BLLIC. For vertical beams,
WLLIC use WLLIC. The location input must be physically within the end points of beam IJ. In the
example shown, a load-interaction curve is defined for beam number 7, which is a fore-aft
beam, at FS 1160.

RUPRAT Beam IJ will rupture when the maximum load ratio for this interaction curve exceeds RUPRAT.
If the input data on cards 2900 and 3000 define a strength envelope which at any point would
cause complete failure of the structure represented by beam IJ, then RUPRAT = 1.0 would be
appropriate. A very large value (RUPRAT = 1000) will guarantee that beam rupture is not
triggered by the load-interaction curve calculations.

REMARKS:

- (1) Optional data card. NLIC on card 0060 defines the number of these cards to be input.
- (2) For each load-interaction curve, cards 2800, 2900 and 3000 are input in sequence, before the next 2800-3000 series. In other words, the 2800-3000 card sequence is repeated NLIC times.
- (3) Section 3.1 describes the load-interaction calculations and data.
- (4) Format for this card is (6I5, 4E10.0).

KRASH INPUT DATA

CARDS 2900: LOAD INTERACTION CURVE DATA

DESCRIPTION: Defines the maximum load levels along the positive and negative x and y load axes.

FORMAT AND EXAMPLE:

0	1	2	3	4	5	6	7	8
12345678901	2345678901	2345678901	2345678901	2345678901	2345678901	2345678901	2345678901	234567890
			FMXLIC1	FMXLIC2	FMXLIC3	FMXLIC4		
			254000.	74.0E06	-254000.	-74.0E06		2900

FIELD

CONTENTS

FMXLIC1 Maximum load levels along the positive and negative x and y load axes. Sequence is as follows:

FMXLIC2

FMXLIC3

FMXLIC4

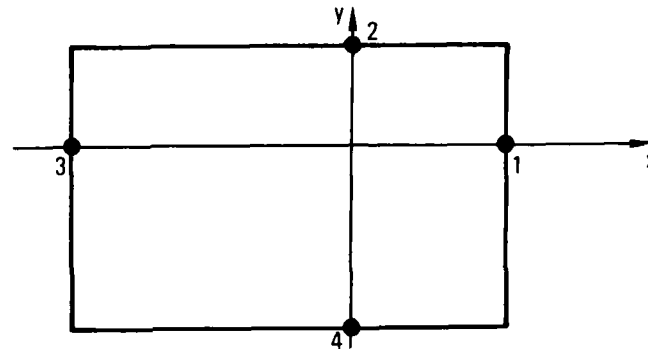
1 = + x axis

2 = + y

3 = - x

4 = - y

These lines form a rectangular load-interaction strength envelope that looks like:



REMARKS:

- (1) Optional data card. NLIC on card 0060 defines the number of these cards to be input.
- (2) For each load-interaction curve, cards 2800, 2900 and 3000 are input in sequence, before the next 2800-3000 series. In other words, the 2800-3000 card sequence is repeated NLIC times.
- (3) Section 3.1 describes the load-interaction calculations and data.
- (4) Format for this card is (30X, 4E10.0).
- (5) A zero or blank input for any of these 4 values will invoke a default value of 1.E20 pounds or inch-pounds.
- (6) FMXLIC3 and FMXLIC4 are input as negative numbers.

KRASH INPUT DATA

CARDS 3000: **LOAD INTERACTION CURVE DATA**

DESCRIPTION: Defines the intercepts for sloping load interaction lines and mirror image flags for generating these lines in other load quadrants.

FORMAT AND EXAMPLE:

0	1	2	3	4	5	6	7	8
1	2	3	4	5	6	7	8	9
0	1	2	3	4	5	6	7	8
1	2	3	4	5	6	7	8	9
MX1	MX2	FLIC1	FLIC2					
1	1	1500.	30.E06					3000

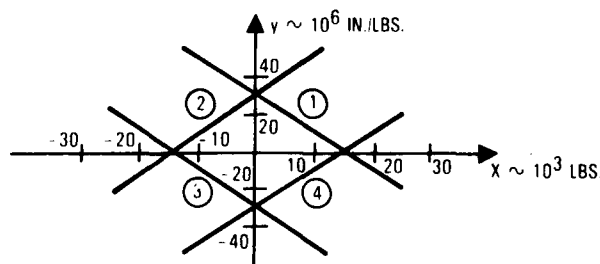
FIELD CONTENTS

MX1 Mirror image flags defining additional load-interaction lines that are generated internally in
MX2 KRASH, based on the line defined by FLIC1 and FLIC2. The following combinations are possible:

MX1	MX2	RESULT	Total No. of L.I. Lines
0	0	No mirror images generated	1
0	1	Mirror about y axis only	2
1	0	Mirror about x axis only	2
1	1	Mirror about x and y axes	4

FLIC1 Intercept of sloping load-interaction line with x (FLIC1) and y (FLIC2) axes. These two
FLIC2 numbers define a single load interaction line, while MX1 and MX2 can be used to generate additional lines which are symmetrical about the x, y or both axes.

- REMARKS:
- (1) Optional data. NLIC on Card 2800 defines the number of these cards to be input
 - (2) For each load-interaction curve, cards 2800, 2900 and 3000 are input in sequence, before the next 2800-3000 series. In other words, the 2800-3000 card sequence is repeated NLIC times.
 - (3) Section 3.1 describes the load-interaction calculations and data.
 - (4) Format for this card is (215, 2E10.0).
 - (5) For each load-interaction curve, a maximum of 20 load-interaction lines are allowed. The limit of 20 includes any lines generated by KRASH through nonzero inputs of MX1 and MX2.
 - (6) The example data will generate the following load-interaction strength envelope:



Load-interaction line 1 is generated by the user-input FLIC1 and FLIC2. Lines 2-4 are generated by KRASH because MX1 = MX2 = 1.

KRASH INPUT DATA

CARDS 3010: **LOAD INTERACTION CURVE DATA**

DESCRIPTION: Defines water line at forward and aft ends of segment for which shear and moment loads are to be summed.

FORMAT AND EXAMPLE:

0	1	2	3	4	5	6	7	8
1	2	3	4	5	6	7	8	9
WLSMF	WLSMA							
215.7	206.4							

FIELD CONTENTS

WLSMF Water line at beam forward end.
WLSMA Water line at beam aft end.

REMARKS: (1) Optional data card. Use only if WSMI on card 2800 is > 0.
 (2) Beam number (IJ) is defined.
 (3) Format for this card is (2E10.0).

KRASH INPUT DATA

CARDS 3020: LOAD INTERACTION CURVE DATA

DESCRIPTION: Defines masses located at station for which shear and moment loads are to be summed.

FORMAT AND EXAMPLE:

0		1		2		3		4		5		6		7		8		
1	2	3	4	5	6	7	8	9	0	1	2	3	4	5	6	7	8	9
IJSM1	IJSM2	IJSM3	IJSM4	IJSM5	IJSM6	IJSM7	IJSM8	IJSM9	IJSM10	IJSM11	IJSM12	IJSM13	IJSM14					
33	41	49	57	65	84	104	105	118	119									

FIELD CONTENTS

IJSM1 Mass Point Number (Right Justified Integer)
 thru
 IJSM14

REMARKS: (1) Optional data card. Use only if NSMI on card 2800 is > 0.
 (2) Masses designed. IJSM1 thru IJSM14 must all be at same FS or BL station.
 (3) 14 masses per card. Use NSMI/14 cards.
 (4) Format for this card is (14I5).

KRASH INPUT DATA

CARDS 3100: MISCELLANEOUS MASS POINT PARAMETERS

DESCRIPTION: Defines any nonzero aerodynamic lift forces, angular moments of rotating masses, and mass cross products of inertia for mass points in the KRASH model.

FORMAT AND EXAMPLE:

0	1	2	3	4	5	6	7	8
1	2	3	4	5	6	7	8	9
1	LC	HEX	HEY	HEZ	XYI	YZI	XZI	NHSY
7	0.0	100.0	0.0	0.0	1.3	-3.3	0.0	0
								3100

FIELD

CONTENTS

I Mass Point Number (Right Justified Integer)
 LC Lift Coefficient For Aerodynamic Force, Positive Up
 HEX Angular Momentum of Rotating Masses About Mass Point X-Axis – Inch * Pound * Second
 HEY Angular Momentum of Rotating Masses About Mass Point Y-Axis – Inch * Pound * Second
 HEZ Angular Momentum of Rotating Masses About Mass Point Z-Axis – Inch * Pound * Second
 XYI Mass Cross Product of Inertia in Mass Point X-Y Plane – Inch * Pound * Second **2
 YZI Mass Cross Product of Inertia in Mass Point Y-Z Plane – Inch * Pound * Second **2
 XZI Mass Cross Product of Inertia in Mass Point X-Z Plane – Inch * Pound * Second **2
 NHSY Symmetry flag which defines the signs for HEX, HEY, HEZ for masses on the right side of the airplane, generated by subroutine GENMOD, if RUNMOD on card 110 is 2.

REMARKS:

- (1) Optional data card(s).
- (2) 'NHI' on card 0050 specifies the number of these cards for input.
- (3) Blank entries are read as zero.
- (4) The airplane weight is multiplied by the lift coefficient to generate an aerodynamic lift force on the mass point. This lift acts upward in ground axes.
- (5) Format for this card is (I2, E8.0, 6E10.0, I2)
- (6) NHSY = 0 corresponds to a symmetrical model (counter-rotating engines), so that

HEX-RIGHT = - HEX LEFT
 HEY-RIGHT = + HEY LEFT
 HEZ-RIGHT = - HEZ LEFT

NHSY = 1 corresponds to an anti-symmetrical model (engines rotate in same direction), so that

HEX-RIGHT = + HEX LEFT
 HEY-RIGHT = - HEY LEFT
 HEZ-RIGHT = + HEZ LEFT

KRASH INPUT DATA

CARD 3200:

MASS POINT EULER ANGLES

DESCRIPTION: Defines for any mass point in the KRASH model three Euler angles to arbitrarily rotate the mass point or body coordinate system relative to the airplane coordinate system.

FORMAT AND EXAMPLE:

0										1										2										3										4										5										6										7										8									
1234567890										1234567890										1234567890										1234567890										1234567890										1234567890										1234567890										1234567890										1234567890									
1										PHIDP										THEDP										IDP																																																											
3										0.157										0.0										0.0																																								3200																			

FIELD

CONTENTS

I Mass Point Number (Right Justified Integer)
 PHIDP Roll Euler Angle about Airplane X-Axis - Radians
 THEDP Pitch Euler Angle about Airplane Y-Axis - Radians
 PSIDP Yaw Euler Angle about Airplane Z-Axis - Radians

REMARKS:

- (1) Optional data card(s).
- (2) "NPH" on card 0050 specifies the number of these cards for input.
- (3) Euler angles are order-dependent rotations. The order is PSIDP, THEDP, PHIDP.
- (4) Blank entries are read as zero.
- (5) These angles relate the mass-fixed axes to the airplane axes. Normally these axes coincide and therefore the angles are zero. If mass inertia were available in an inclined axis system the user might want to utilize this option. Another reason for inclining mass axes away from the airplane axes is to enable the user to orient an external spring in a direction that doesn't coincide with any of the airplane axes (external springs must point along one of the mass fixed axes).
- (6) Roll angle positive when mass axes are "right-wing-down" relative to cg axes.
 Pitch angle positive when mass axes are "nose-up" relative to cg axes.
 Yaw angle positive when mass axes are "nose-right" relative to cg axes.
- (7) Format for this card (I5, 5X, 3E10,0).

KRASH INPUT DATA

CARDS 3300: MASS POINT AERODYNAMIC COEFFICIENTS

DESCRIPTION: Defines for any mass point 6 aerodynamic load coefficients to be used to calculate aerodynamic loads.

FORMAT AND EXAMPLE:

0	1	2	3	4	5	6	7	8
12345678901	2345678901	2345678901	2345678901	2345678901	2345678901	2345678901	2345678901	234567890
I		CXAIR	CYAIR	CZAIR	CLAIR	CMAIR	CNAIR	
13		-137.	0.	-1500.	3500.	5200.	7100.	3300

FIELD

CONTENTS

I Mass point number
CXAIR Aerodynamic drag coefficient, in²
CYAIR Aerodynamic side force coefficient, in²
CZAIR Aerodynamic lift coefficient, in²
CLAIR Aerodynamic rolling moment coefficient, in³
CMAIR Aerodynamic pitching moment coefficient, in³
CNAIR Aerodynamic yawing moment coefficient, in³

REMARKS:

- (1) Optional data card(s).
- (2) NAERO on card 0050 specifies the number of these cards for input.
- (3) The input aerodynamic coefficients are defined as follows:

$$\begin{aligned} \text{CXAIR} &= S * C_X \alpha \\ \text{CYAIR} &= S * C_Y \beta \\ \text{CZAIR} &= S * C_Z \alpha \\ \text{CLAIR} &= S * b * C_L \beta \\ \text{CMAIR} &= S * \bar{c} * C_M \alpha \\ \text{CNAIR} &= S * b * C_N \beta \end{aligned}$$

where

S = Reference area, in²
b = Reference span, in
 $\bar{c}$ = Reference mean aerodynamic chord, in.
alpha = Angle of attack, rad. Positive when mass is nose up relative to its velocity vector.
beta = Sideslip angle, rad. Positive when mass is nose left relative to its velocity vector.
CXalpha = Slope of aerodynamic drag (positive forward) versus alpha, 1/rad
CYbeta = Slope of aerodynamic side force (positive right) versus beta, 1/rad
CZalpha = Slope of aerodynamic vertical force (positive down) versus alpha, 1/rad

KRASH INPUT DATA

REMARKS:
(Continued)

CLbeta = Slope of aerodynamic roll moment (positive right wing down) versus
beta, 1/rad
CMalpha = Slope of aerodynamic pitch moment (positive nose up) versus alpha, 1/rad
CNbeta = Slope of aerodynamic yaw moment (positive nose right) versus beta, 1/rad

- (4) All data refer to the local mass defined by I, not to the entire airplane.
- (5) Aerodynamic loads at zero ALPHA are not included in the calculations. If necessary, these can be included as external forces/moments in the 3300 series cards.
- (6) Aerodynamic loads using these coefficients are not included in the balanced initial conditions coding.
- (7) The format for this card is (15,5X,6E10.0).

KRASH INPUT DATA

CARDS 3400:

MASS POINT TIME HISTORY ACCELERATION PARAMETERS

DESCRIPTION: Defines the mass point number, degree-of-freedom, and number of data points to specify an acceleration or load time history for any mass point in the KRASH model.

FORMAT AND EXAMPLE:

[illegible]

<u>FIELD</u>	<u>CONTENTS</u>
I	Mass Point Number.
L	Degree-of-Freedom where L = 1, 2, 3, 4, 5, 6 corresponds to X, Y, Z, θ_X , θ_Y , θ_Z in the Mass Point Coordinate System
NP	Number of Data Points in the Table that specifies the Acceleration or Load Time History
NCODE	Flag defining whether the input table is of mass point acceleration or applied load.

REMARKS:

- (1) Optional data card(s).
- (2) "NACC" on card 0040 specifies the number of these cards for input.
- (3) All entries are right justified integers.
- (4) Each use of this card requires that "NP" number of the 3500-series cards be used.
- (5) The masses must be input in sequence starting with the lower numbered masses.
- (6) Format for this card is 4I5.
- (7) NCODE = 0 for acceleration input table
NCODE = 1 for force/moment input table
- (8) It is permissible to input forces for some masses and accelerations for other masses.
If both types are input for the same mass, the accelerations will predominate.

KRASH INPUT DATA

CARDS 3500: MASS POINT ACCELERATION OR LOAD TIME HISTORY DATA TABLE

DESCRIPTION: Defines a table of time and acceleration or load data points for each mass point specified on the 3400-series cards.

FORMAT AND EXAMPLE:

0	1	2	3	4	5	6	7	8
12345678901	2345678901	2345678901	2345678901	2345678901	2345678901	2345678901	2345678901	234567890
T	ACCEL							
0.01	-0.6							3500

FIELD CONTENTS

T Time - Seconds
 Accel Acceleration G's or Radians per Second **2
 or Loads Pounds or Inch-Pounds

- REMARKS:
- (1) Optional data cards.
 - (2) For each of the "NACC" number of 3400-series cards, "NP" number of these cards are required.
 - (3) Within each set of data, the "NP" cards must be arranged in ascending order of time.
 - (4) Each set of data must be ordered to correspond with the 3400 series cards.
 - (5) Blank entries are read as zero.
 - (6) A maximum of 5000 acceleration times are allowed. For example, if accelerations are applied to 50 masses, the time history of each location can not exceed a curve consisting of 100 points.
 - (7) The values of acceleration or load are in mass axes, with translational accelerations in g's and rotational accelerations in rad/sec². Loads are in pounds or inch-pounds. (See Equation 1-117 Volume I).
 - (8) Format for this card is 2E10.0.

KRASH INPUT DATA

CARDS 3600: DIRECT INPUT OF BEAM ELEMENT 6X6 STIFFNESS MATRIX

DESCRIPTION: Defines the end points and 6x6 stiffness matrix terms for any beam element in the KRASH model.

FORMAT AND EXAMPLE:

0	1	2	3	4	5	6	7	8
1	2	3	4	5	6	7	8	9
M	I	N	J					
	2	1	7					2400

0	1	2	3	4	5	6	7	8
1	2	3	4	5	6	7	8	9
	K11	K12	K13	K14	K15	K16		
	3500.0	0.0	0.0	0.0	0.0	0.0		2401

0	1	2	3	4	5	6	7	8
1	2	3	4	5	6	7	8	9
	K21	K22	K23	K24	K25	K26		
	0.0	1.7E07	0.0	0.0	0.0	-2.2E05		2402

0	1	2	3	4	5	6	7	8
1	2	3	4	5	6	7	8	9
	K31	K32	K33	K34	K35	K36		
	0.0	0.0	1.7E07	0.0	0.3E05	0.0		2403

0	1	2	3	4	5	6	7	8
1	2	3	4	5	6	7	8	9
	K41	K42	K43	K44	K45	K46		
	0.0	0.0	0.0	15200.0	0.0	0.0		2404

0	1	2	3	4	5	6	7	8
1	2	3	4	5	6	7	8	9
	K51	K52	K53	K54	K55	K56		
	0.0	0.0	0.3E06	0.0	3.5E09	0.0		2405

0	1	2	3	4	5	6	7	8
1	2	3	4	5	6	7	8	9
	K61	K62	K63	K64	K65	K66		
	0.0	-2.2E05	0.0	0.0	0.0	3.5E09		2406

KRASH INPUT DATA

CARDS 3600: DIRECT INPUT OF BEAM ELEMENT 6X6 STIFFNESS MATRIX (Continued)

<u>FIELD</u>	<u>CONTENTS</u>
M	Massless Node Point Number at end "I" (Right Justified Integer)
I	Mass Point Number at end "I" (Right Justified Integer)
N	Massless Node Point Number at end "J" (Right Justified Integer)
J	Mass Point Number at end "J" (Right Justified Integer)
KIJ	Stiffness Matrix Terms - Pounds per Inch or Inch * Pounds per Radian

REMARKS:

- (1) Optional data cards.
- (2) "NKM" on card 0050 specifies the number of these card sets for input.
- (3) Blank entries are read as zero.
- (4) The beam element must be included on the 0900-series cards.
- (5) The stiffness data on these cards will override any values calculated with the beam element section properties on the 0900-series cards.
- (6) The input 6x6 stiffness matrix corresponds to the lower right-hand quadrant of a full 12x12 beam element stiffness matrix, shown as Equation (1-23) in Volume I.
- (7) Entries requiring scientific notation (X.XEXX) should be right justified.
- (8) Format for the beam identification card is 2(I2, I3).
- (9) Format for the stiffness matrix data cards is 6E10.0.

KRASH INPUT DATA

CARDS 3700-3800:

MASS POINT POSITION (STRUCTURE DEFORMATION) PRINTER PLOT PARAMETERS

DESCRIPTION: Defines the planar view, scale factors, and mass point numbers for each mass point position (structure deformation) printer plot.

FORMAT AND EXAMPLE:

0	1	2	3	4	5	6	7	8
12345678901	2345678901	2345678901	2345678901	2345678901	2345678901	2345678901	2345678901	234567890
NTPL	NMPTS	ISCALE	XSCALE	YSCALE				
1	10	3	10.0	10.0				3700

0	1	2	3	4	5	6	7	8
12345678901	2345678901	2345678901	2345678901	2345678901	2345678901	2345678901	2345678901	234567890
M1	M2	M3	M4	M5	M6	M7	M8	M9
1	2	5	6	7	11	13	14	21

FIELD

CONTENTS

NTPL Flag to select Planar View where NTPL = 1, 2, 3 corresponds to top, side, and frontal views, respectively (Right Justified Integer)

NMPTS Number of Mass Points (Right Justified Integer - Maximum allowed is 50)

ISCALE: Flag to Select Scaling Option as follows (Right Justified Integer):

ISCALE	TYPE OF SCALING
0	Automatic scaling where horizontal and vertical plot axes scales are selected independently based on the corresponding largest mass point displacement components.
1	Automatic scaling where horizontal and vertical plot axes scales are set equal based on largest mass point displacement component.
3	User defined scaling

XSCALE Horizontal Scale Factor required if "ISCALE" = 3

YSCALE Vertical Scale Factor required if "ISCALE" = 3

M1 Mass Point Number (Right Justified Integer)

REMARKS:

- (1) Optional data cards.
- (2) "NPLT" on card 0140 specifies the number of these card sets for input.
- (3) "NTPL," "NMPTS," and "M1" must be nonzero.
- (4) Blank entries are read as zero.
- (5) Scale factor units are inches of mass point displacement per inch of paper.
- (6) Entries requiring scientific notation (X.XEXX) should be right justified.
- (7) Recommend ISCALE = 3 if user plans to compare or overlay plots at different time periods.
- (8) Format for card 3700 type is (315.5X,2E10.0).
- (9) Format for card 3800 type is 1415.

KRASH INPUT DATA

CARDS 3900:

MASS POINT PRINTER PLOT PARAMETERS

DESCRIPTION: Defines the mass point number and flags to specify which mass point output quantity time histories will be printer plotted.

FORMAT AND EXAMPLE:

0										1										2										3										4										5										6										7										8									
12345678901										2345678901										2345678901										2345678901										2345678901										2345678901										2345678901										2345678901										2345678901									
1	MP1	MP2	MP3	MP4	MP5	MP6	MP7	MP8	MP9																																																																																
3	0	1	0	1	0	0	1	0	1																																																																																
																																								3900																																																	

<u>FIELD</u>	<u>CONTENTS</u>
I	Mass Point Number
MP1	Flag for Linear Displacements (X, Y, Z - Inches) in the Ground Coordinate System
MP2	Flag for Euler Angles (PHI, THETA, PSI - Radians) in the Airplane Coordinate System
MP3	Flag for Linear Velocities (X, Y, Z - Inches per Second) in the Ground Coordinate System
MP4	Flag for Linear Velocities (U, V, W - Inches per Second) in the Mass Point or Body Coordinate System
MP5	Flag for Angular Velocities (P, Q, R - Radians per Second) in the Mass Point or Body Coordinate System
MP6	Flag for Unfiltered Linear Accelerations (X, Y, Z - G's) in the Mass Point or Body Coordinate System
MP7	Flag for Filtered Linear Accelerations (X, Y, Z - G's) in the Mass Point or Body Coordinate System
MP8	Flag for Angular Accelerations (P, Q, R - Radians per Second**2) in the Mass Point or Body Coordinate System
MP9	Flag for Impulse (X, Y, Z in G-sec., P, Q, R in (RAD Per Sec) in Mass Point or Body Coordinate Axes for Filtered Data

REMARKS:

- (1) Optional data card(s).
- (2) "NMEP" on card 0140 specifies the number of these cards for input.
- (3) All entries are right justified integers.
- (4) "I" must be nonzero.
- (5) Blank entries are read as zero.
- (6) Flags for printer plot time histories are defined as follows:
0 = No
1 = Yes
- (7) Format for this card is 10I5.

KRASH INPUT DATA

CARDS 4000: MASSLESS NODE POINT PRINTER PLOT PARAMETERS

DESCRIPTION: Defines the massless node point number, mass point number, and flags to specify which massless node point output quantity time histories will be printer plotted.

FORMAT AND EXAMPLE:

0										1										2										3										4										5										6										7										8									
1234567890										1234567890										1234567890										1234567890										1234567890										1234567890										1234567890										1234567890										1234567890									
M		I		NP1		NP2		NP3		NP4		NP5		NP6																																																																											
1		7		0		1		0		1		0		0										4000																																																																	

KRASH INPUT DATA

CARDS 4100:

BEAM ELEMENT LOADS PRINTER PLOT PARAMETERS

<u>DESCRIPTION:</u>	Defines the beam element number and flags to specify which beam element internal load time histories will be printer plotted.
----------------------------	---

FORMAT AND EXAMPLE:

[illegible]

<u>FIELD</u>	<u>CONTENTS</u>
IJ	Beam Element Number
BFP1	Flag for Axial and Shear Forces (FX, FY, FZ - Pounds)
BFP2	Flag for Torque and Bending Moments at End "I" (MX, MY, MZ - Inch * Pounds)
BFP3	Flag for Torque and Bending Moments at End "J" (MX, MY, MZ - Inch * Pounds)
BFP4	Flag for choosing between beam axis loads or loads in mass axes.
<u>REMARKS:</u>	(1) Optional data card(s). (2) "NBFP" on card 0140 specifies the number of these cards for input. (3) All entries are right justified integers. (4) "IJ" must be nonzero. (5) Blank entries are read as zero. (6) Flags for printer plot time histories are defined as follows: 0 = No 1 = Yes (7) If BFP4 = 0, then all load data are in the beam element coordinate system shown in Figure 2-5. If BFP4 = 1, then all load data are in the mass point coordinate system at mass i or j, as appropriate. (8) If BFP4 = 1, then BFP1 through BFP3 control plotting of the following: BFP1: FX,FY,FZ at mass I, in mass point coordinate system BFP2: FX,FY,FZ at mass J, in mass point coordinate system BFP3: MYI and MYJ, moments about y axis in each mass point coordinate system. (9) Format for this card is 5I5.

AD-A161 801

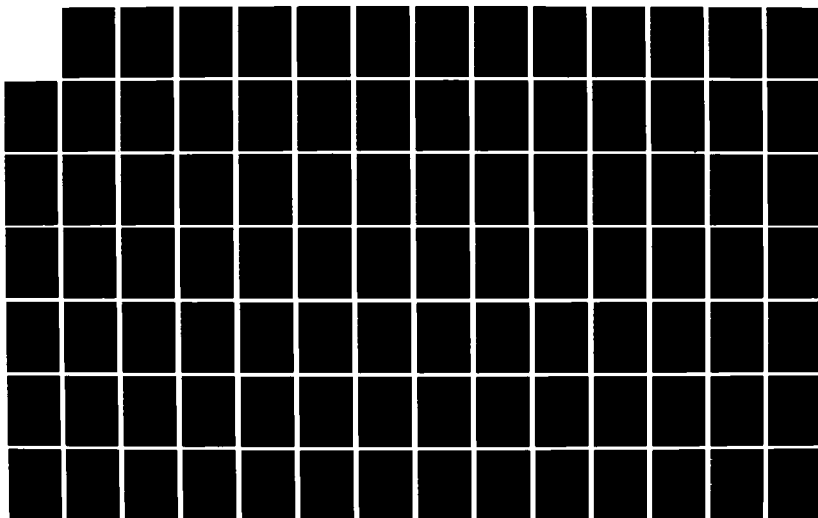
KRASH 85 USER'S GUIDE - INPUT/OUTPUT FORMAT(U)
LOCKHEED-CALIFORNIA CO BURBANK M A GANON ET AL. JUL 85
LR-30777 DOT/FAA/CT-85-10 DTF803-83-C-00004

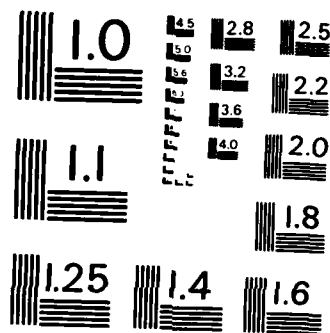
2/3

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NL





MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

KRASH INPUT DATA

CARDS 4200

BEAM ELEMENT DEFLECTION-ROTATION PRINTER PLOT PARAMETERS

DESCRIPTION

Defines the beam element number and flags to specify which beam element deflection and rotation time histories will be printer plotted.

FORMAT AND EXAMPLE:

0	1	2	3	4	5	6	7	8
12345678901	2345678901	2345678901	2345678901	2345678901	2345678901	2345678901	2345678901	234567890
IJ	BDP1	BDP2	BDP3					
3	0	0	1					4200

FIELD

CONTENTS

IJ Beam Element Number
 BDP1 Flag for Deflection Differences of End "J" and End "I" (X, Y, Z - Inches)
 BDP2 Flag for Rotation Differences of End "J" and End "I" (Phi, Theta, Psi - Radians)
 BDP3 Flag for Rotation Sums of End "J" and End "I" (Phi, Theta, Psi - Radians)

REMARKS

- (1) Optional data card(s).
- (2) "NBDP" on card 0140 specifies the number of these cards for input.
- (3) All entries are right justified integers.
- (4) "IJ" must be nonzero.
- (5) Blank entries are read as zero.
- (6) Flags for printer plot time histories are defined as follows:
 0 = No
 1 = Yes
- (7) All deflection-rotation data is output in the beam element coordinate systems shown in Figure 2-3.
- (8) Format for this card is 4I5.

KRASH INPUT DATA

CARDS 4300:

BEAM ELEMENT STRESS RATIO PRINTER PLOT PARAMETERS

DESCRIPTION: Defines the beam element number and flags to specify which beam element stress ratio time histories will be printer plotted.

FORMAT AND EXAMPLE:

0		1		2		3		4		5		6		7		8	
1	2	3	4	5	6	7	8	9	0	1	2	3	4	5	6	7	8
IJ	STP1	STP2	STP3	STP4	STP5												
7	0	1	1	0	0											4300	

<u>FIELD</u>	<u>CONTENTS</u>
1J	Beam Element Number
STP1	Flag for Stress Ratio for Top and Bottom Fibers Using Maximum Shear Stress Theory
STP2	Flag for Stress Ratio of Left and Right Fibers Using Maximum Shear Stress Theory
STP3	Flag for Stress Ratio of Top and Bottom Fibers using Constant Energy of Distortion Theory
STP4	Flag for Stress Ratio of Left and Right Fibers Using Constant Energy of Distortion Theory
STP5	Flag for Stress Ratio of Tension-Only, Compression-Only, and Axial Buckling Loads

REMARKS

- (1) Optional data card(s).
- (2) "NSTP" on card 0140 specifies the number of these cards for input.
- (3) All entries are right justified integers.
- (4) "IJ" must be nonzero.
- (5) Blank entries are read as zero.
- (6) Flags for printer plot time histories are defined as follows:
0 = No
1 = Yes
- (7) Stress parameters must be provided for the beam elements on the 0900-series cards.
- (8) "NSC" on card 0050 must be flagged "yes."
- (9) Format for this card is 615.

KRASH INPUT DATA

CARDS 4400:

EXTERNAL CRUSHING SPRING LOAD-DEFLECTION PRINTER PLOT PARAMETERS

DESCRIPTION: Defines the end point and flags to specify which external crushing spring load and deflection time histories will be printer plotted.

FORMAT AND EXAMPLE:

[illegible]

FIELD

CONTENTS

J	Mass Point Number
M	Massless Node Point Number
SEP1	Flag for Axial Deflection (Inches)
SEP2	Flag for Axial Loads (Pounds)

REMARKS:

- (1) Optional data card(s).
- (2) "NSEP" on card 0140 specifies the number of these cards for input.
- (3) All entries are right justified integers.
- (4) "J" *must be nonzero*.
- (5) Blank entries are read as zero.
- (6) Flags for printer plot time histories are defined as follows:
0 = No
1 = Yes
- (7) All external crushing springs attached to the same mass point/massless node point will be printer plotted if that end point is specified.
- (8) Format for this card is 4I5.

KRASH INPUT DATA

CARDS 4500:

BEAM ELEMENT STRAIN AND DAMPING ENERGY PRINTER PLOT PARAMETERS

DESCRIPTION: Defines the beam element number and flags to specify which beam internal element strain and damping energy time history will be printer plotted

FORMAT AND EXAMPLE:

[illegible]

FIELD

CONTENTS

IJ	Beam Element Number
ENG1	Flag for Strain Energy (in.-lb.)
ENG2	Flag for Damping Energy (in.-lb.)

REMARKS:

- (1) Optional data cards.
- (2) "NENP" on card 0140 specifies the number of these cards for input.
- (3) All entries must be *right justified*.
- (4) "IJ" must be nonzero.
- (5) *Blank entries are read as zero.*
- (6) Flags for printer plot time histories are defined as follows:
0 = No
1 = Yes
- (7) Format for this card is 3I5.

KRASH INPUT DATA

CARDS 4600: DYNAMIC RESPONSE INDEX (DRI) PRINTER PLOT PARAMETERS

DESCRIPTION: Defines the mass point number of a DRI beam element for dynamic response index (DRI) time history printer plots.

FORMAT AND EXAMPLE:

0	1	2	3	4	5	6	7	8
1	2	3	4	5	6	7	8	9
0	1	2	3	4	5	6	7	8
1	2	3	4	5	6	7	8	9
J								
27								4600

<u>FIELD</u>	<u>CONTENTS</u>
J	Mass Point Number

REMARKS:

- (1) Optional data card(s).
- (2) "NDRP" on card 0140 specifies the number of these cards for input.
- (3) All entries are right justified integers.
- (4) "J" must be nonzero.
- (5) Blank entries are read as zero.
- (6) Flags for printer plot time histories are defined as follows:
 0 = No
 1 = Yes
- (7) The mass point number must be end "J" of a DRI beam element.
- (8) Format for this card is I5.

CARD 4700: END OF DATA

DESCRIPTION: Defines the final card of the input data.

FORMAT AND EXAMPLE:

0	1	2	3	4	5	6	7	8
1	2	3	4	5	6	7	8	9
0	1	2	3	4	5	6	7	8
1	2	3	4	5	6	7	8	9
END								
END								4700

<u>FIELD</u>	<u>CONTENTS</u>
End	The Mnemonic "End" (Left Justified)

REMARKS: (1) Required data card.

2.3 OUTPUT AND SAMPLE CASE

As explained in Section 2.1, the most general case of a KRASH85 analysis involves the use of three separate programs: KRASHIC, MSCTRAN, and KRASH85. Table 2-6 shows a summary of the output from each program. A sample case which models one-half of a transport airplane with 21 masses and 28 internal beams will be used to illustrate the output for each program. This model is illustrated in figure 2-7. This is a test case with special elements for checkout purposes; it does not represent a realistic airplane model.

TABLE 2-6. SUMMARY OF KRASH85 OUTPUT

KRASHIC	KRASH85
• Echo of input data (2 times) • Formatted printout of input data • Miscellaneous calculated data	• Echo of input data (2 times) • Formatted printout of input data • Miscellaneous calculated data • Time histories of model responses • Mass data • Internal beam data • External spring data • Energy data • Summaries at end of run • External spring loading/unloading • Summary of plastic hinge formations • Summary of internal beam yielding and rupture • Summary of energy distribution • Interaction load time-histories • Vehicle c.g. motion time-histories • Time history plots of selected response quantities
MSCTRAN	
• Executive control deck echo • Case control deck echo • Input bulk data deck echo • Sorted bulk data deck echo • Displacement vector • Load vector • Forces of single-point constraint • Forces in bar elements • Element strain energies • Grid point force balance	

2.3.1 KRASHIC Output

2.3.1.1 Echo of Input Data

This is a direct listing of the input data cards for the case being analyzed. Figure 2-8 illustrates this print for the sample case. Each

page of the listing is preceded by a heading which identifies the column number. The sequence numbers are in columns 77 - 80. The first card, with a 1 in column 10, is generated by the Job Control Language (JCL), and is not part of the data set (LT.SAMPLE.DATA in this case) in the user's library. This first card tells the program whether or not to read an additional data set of static deflections. A value of 1 means read the additional data set, 0 means don't read it. The JCL is set up to supply a zero for this card for the first iteration, when no static deflection information is available, and a 1 for all subsequent iterations, when the data are available, as generated by NASTRAN. The listing in figure 2-8 is from the last iteration, and therefore the first card has a 1 in column 10. To reiterate, this card is automatically generated by the JCL; the user does not supply this card.

Cards 10 through 3480 are supplied by the user and represent the basic KRASH85 data set described in Section 2.2. This is the data set referred to as XYZ.DATA in Section 2.1. Note how the dummy title cards serve to segment the data and facilitate reviewing and editing the data set.

Following card 3480 is a set of cards numbered 1 through 76. This is the static deflection data set referred to as XYZ.NASOUT.DATA in Section 2.1. The first six cards of this data set are title cards, the remaining cards are the three deflections and three rotations of each grid point in the NASTRAN model used to solve the static loads problem. Cards 1 through 76 are all generated automatically; the user does not have to develop this data set. The data set will reside in the user's library under the name XYZ.NASOUT.DATA.

The complete echo shown in figure 2-8 is provided twice. One copy can be used to mark up for forming a new data set, while the other copy remains as a clean record of the input for the current case.

2.3.1.2 Formatted Print-Out of Input Data

This section of the print output organizes all the input data into logical groups and prints out the data with self-explanatory identification headings. This output is illustrated in figure 2-9 for the sample case. The data are organized into the following major groups:

- Case title cards
- Program size data
- Acceleration data transfer control parameters
- Program data management control data (restart option)
- Program control data
- Vehicle initial conditions
- Initial mass/node point deflections (read from XYZ.NASOUT.DATA)
- Generalized surface data
- Corresponding mass and beam numbering (RUNMOD = 2 only)
- Mass data
- Node point data (optional)
- External spring data (optional)
- Material properties
- Internal beam data
- Unsymmetrical beam data (optional)
- Plastic hinge and end-fixity data (optional)
- Oleo strut beam data (optional)
- Nonlinear beam data (optional)
- Volume penetration data (optional)
- DRI elements (optional)
- Volume change data (optional)
- Nonstandard maximum deflections (optional)
- Nonstandard maximum forces (optional)
- Load interaction curve sign conventions and curve data (optional)
- Nonzero angular momenta, cross-products of inertia, lift constants (optional)

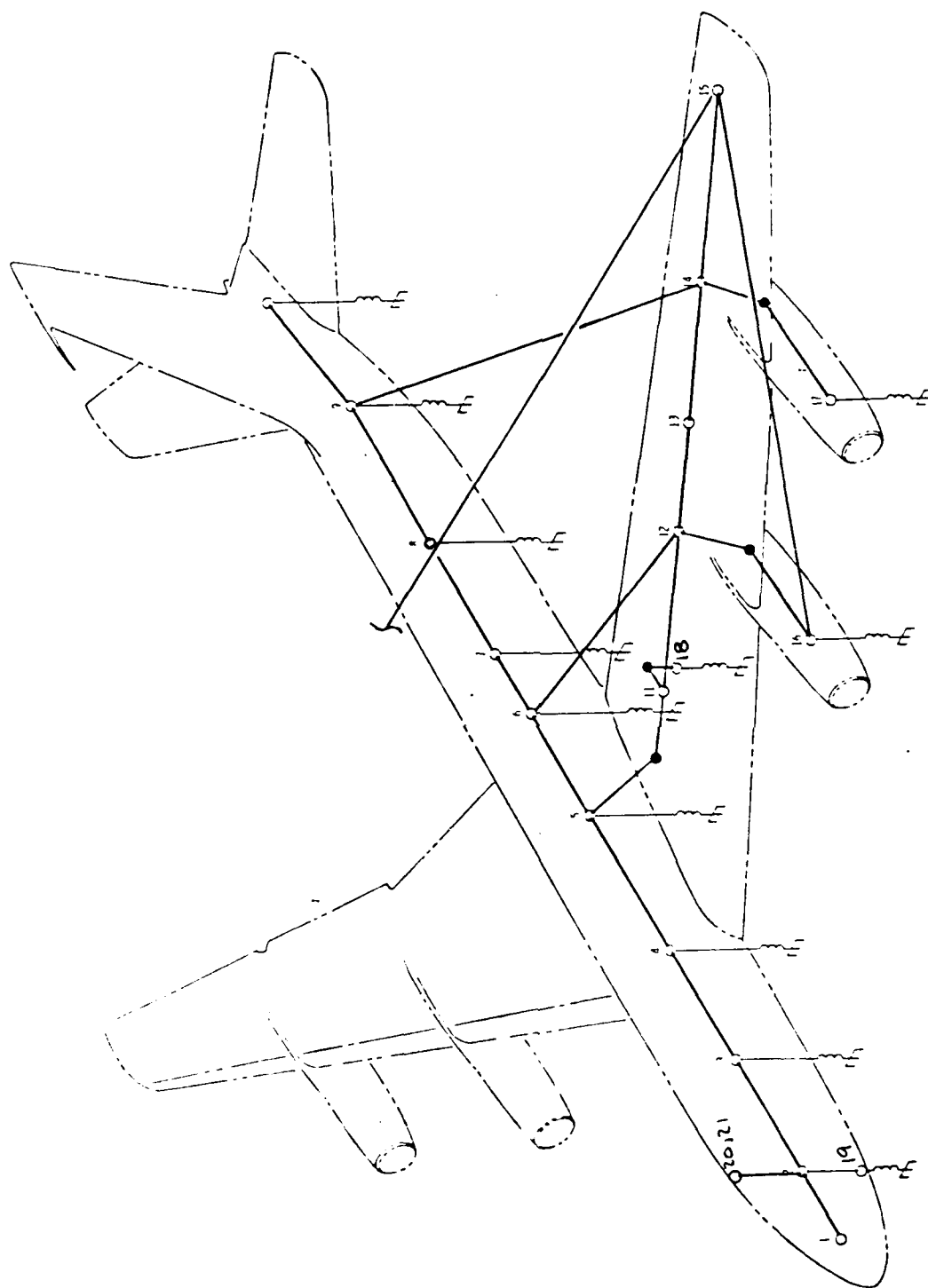


FIGURE 2-7. LARGE TRANSPORT AIRPLANE MODEL - SAMPLE CASE

ECHO OF THE INPUT DATA IN CARD IMAGE FORMAT

	1	2	3	4	5	6	7	8
CARD NO.	1234567890123456789012345678901234567890123456789012345678901234567890							
1	1							
2	LT.SAMPLE.DATA							00000010
3	21 MASS/28 BEAM TEST CASE ONLY-NOT VALID AIRPLANE MODEL							00000020
4	12345678901234567890123456789012345678901234567890123456789012345678901200000030							
5	NM NSP NB NLB NNP NPIN NUB NDRINOLEO NACC MVP NVCH NMTL ND							00000040
6	21 19 28 1 12 10 4 1 2 19 0 0 0 0							00000050
7	NVBM NFBMNVBMNFBMN NKM NHI NPH TOL1 TOL2 TOL3 NSC NICNAERONBOMB							00000060
8	0 2 0 2 0 2 2 1000 1000 1000 1 1 0 1							00000070
9	NSCV NLICNWRGR NBAL ICDICITR							00000080
10	1 15 0 5 1 1							00000090
11	GRAPHICS							00000100
12								00000110
13							200	00000120
14	ONE RESTART AND ONE SAVE CARD FOLLOWS							00000130
15								00000140
16								00000150
17	IPRINT DELTAT TMAX PLOWT FCUT RUNMOD							00000160
18	200 .000050 0.1 0.000 50. 1.							00000170
19	BLANK CARD FOLLOWS							00000180
20								00000190
21	NSF NTF NDE NSPD NED NS NRP NIMP NBC : PRINT DATA							00000200
22	1 1 1 1 1 0 1 0 1							00000210
23	NMEP NNEP NBFP NBDP NSTP NSEP NENP NDRP NPLTNPFCT : PLOT DATA							00000220
24	0 0 6 0 0 0 0 0 0							00000230
25	INITIAL CONDITION DATA : 3 CARDS							00000240
26	3140.00 000.00 300.00							00000250
27	000.00 0.1 000.00							00000260
28	000.00 .01745 000.00 000.00 000.00 0.001.1463E-07							00000270
29	MASS DATA : NM CARDS							00000280
30	1585.0 199.0 0.0 220.0.11514E+05.4 E+05.15 E+05							100000290
31	9064.5 300.0 0.0 218.7.89080E+05.3 E+06.99 E+05							200000300
32	15318.1 460.0 0.0 208.7.16278E+06.96935E+05.10309E+06							300000310
33	13096.0 620.0 0.0 206.0.19627E+06.66715E+05.79389E+05							400000320
34	21752.6 820.0 0.0 200.2.49106E+06.12567E+06.14651E+06							500000330
35	7901.5 960.0 0.0 212.4.81383E+05.12 E+06.2 E+06							600000340
36	9190.7 1040.0 0.0 207.9.87536E+05.14 E+06.2 E+06							700000350
37	9938.4 1200.0 0.0 225.1.88098E+05.18 E+06.3 E+06							800000360
38	5702.0 1359.9 0.0 260.0.96249E+05.41788E+05.26039E+05							900000370
39	6175.2 1570.0 0.0 302.3.21530E+06.10798E+06.15863E+06							1000000380
40	9670.6 801.3 118.3 188.3.15213E+05.13858E+06.36 E+06							1100000390
41	10065.6 852.3 271.8 203.1.19510E+05.12263E+06.3 E+06							1200000400
42	5286.5 943.5 430.7 219.9.72715E+04.52619E+05.11 E+06							1300000410
43	3759.0 1045.8 583.5 243.5.44083E+04.25823E+05.60 E+05							1400000420
44	1542.3 1112.6 740.6 255.1.16708E+04.90137E+04.18 E+05							1500000430
45	5400.0 719.0 321.6 165.8 3651.56 25746. 29374.6							1600000440
46	5151.0 902.8 551.6 188.1 3712. 24588.2 28178.							1700000450
47	1922.0 887.0 131.6 90.7 371. 1600. 2000.							1800000460
48	238.0 279.0 0.0 85.0 24. 300. 500.							1900000470
49	1000. 300.0 0.0 238.7 1000. 1000. 1000.							2000000480
50	1000. 300.0 0.0 238.7 1000. 1000. 1000.							2100000490

FIGURE 2-8. ECHO OF THE INPUT DATA (SHEET 1 OF 9)

ECHO OF THE INPUT DATA IN CARD IMAGE FORMAT

CARD NO.	1	2	3	4	5	6	7	8
51	NODE POINT DATA : NNP CARDS							
52	1	5	775.1	48.0	181.0			00000500
53	1	11	773.9	118.3	186.3			00000510
54	2	11	887.0	131.6	179.7			00000520
55	3	11	887.0	131.6	179.7			00000530
56	1	12	811.8	321.6	199.6			00000540
57	1	14	994.5	551.6	220.5			00000550
58	1	15	1148.0	740.6	261.3			00000560
59	2	15	1112.6	740.6	255.1			00000570
60	1	16	735.7	321.6	199.6			00000580
61	2	16	719.0	321.6	165.8			00000590
62	1	17	918.4	551.6	220.5			00000600
63	1	2	279.0	0.0	147.5			00000610
64	EXTERNAL SPRING DATA : 2 X NSP CARDS							
65	1	3	70.	0.35	175000.			00000620
66	2	3	82.7	0.35	300000.0			00000630
67	3	3	72.7	0.35	100000.0			00000640
68	4	3	70.0	0.35	300000.0			00000650
69	5	3	64.2	0.35	300000.0			00000660
70	6	3	76.4	0.35	300000.0			00000670
71	7	3	69.9	0.35	100000.0			00000680
72	8	3	69.1	0.35	100000.0			00000690
73	9	3	64.0	0.35	300000.0			00000700
74	10	3	82.0	0.35	300000.0			00000710
75	11	3	28.	0.35	100000.			00000720
76	12	3	14.	0.35	100000.			00000730
77	13	3	11.	0.35	100000.			00000740
78	14	3	7.	0.35	100000.			00000750
79	15	3	3.	0.35	100000.			00000760
80	16	3	29.8	0.35	272000.			00000770
81	17	3	28.	0.35	272000.			00000780
82	18	3	19.65	0.30	100000.			00000790
83	19	3	16.45	0.30	100000.			00000800
84	1.3	1.5	1.6	10.	70000.	7000.	0.	00000810
85	1.3	1.5	1.6	10.	140000.	14000.	0.00	00000820
86	1.0	6.0	10.	21.	115000.	90000.	0.00	00000830
87	1.0	1.1	2.0	3.0	340000.	200000.	0.00	00000840
88	1.0	1.1	2.0	3.0	340000.	200000.	0.00	00000850
89	1.0	1.1	2.0	3.0	340000.	200000.	0.00	00000860
90	1.	6.	10.	21.	60000.	48000.	0.00	00000870
91	1.	6.	10.	21.	68000.	48000.	0.00	00000880
92	1.	1.1	2.0	3.	300000.	30000.	0.00	00000890
93	1.	1.1	2.0	3.	300000.	30000.	0.00	00000900
94	1.	1.5	2.	7.	330000.	330000.	0.00	00000910
95	1.	1.5	2.	7.	330000.	330000.	0.00	00000920
96	1.	1.5	2.	7.	330000.	330000.	0.00	00000930
97	1.	1.5	2.	7.	330000.	330000.	0.00	00000940
98	1.	1.5	2.	7.	330000.	330000.	0.00	00000950
99	1.	8.	9.	16.	10000.	30000.	0.00	00000960
100	1.	8.	9.	16.	10000.	30000.	0.00	00000970
101	2.	2.001	8.05	8.051	62200.	294700.	.02	00000980

FIGURE 2-8. ECHO OF THE INPUT DATA (SHEET 2 OF 9)

ECHO OF THE INPUT DATA IN CARD IMAGE FORMAT

	1	2	3	4	5	6	7	8	
CARD NO.	123456789012345678901234567890123456789012345678901234567890								
102	2.	2.001	5.75	5.751	16150.	51500.	.02	00001010	
103	INTERNAL BEAM DATA : NB CARDS							00001020	
104	1	2	32.00	0.00	6.20E+04	3.70E+04	0.00 96.0 96.0	500001030	
105	2	3	36.00	0.00	7.70E+04	4.30E+04	0.00 99.0 99.0	500001040	
106	3	4	36.00	0.00	8.60E+04	4.30E+04	0.00 56.0 56.0	500001050	
107	4	5	59.00	0.00	13.60E+04	4.65E+04	0.00 56.0 56.0	500001060	
108	5	6	59.00	0.00	11.60E+04	4.65E+04	0.00 66.0 66.0	500001070	
109	6	7	57.00	0.00	13.60E+04	5.70E+04	0.00 88.0 88.0	500001080	
110	7	8	48.00	0.00	11.40E+04	6.20E+04	0.00 91.0 91.0	500001090	
111	8	9	37.00	0.00	5.60E+04	3.35E+04	0.00 51.0 51.0	500001100	
112	9	10	25.00	0.00	9.00E+04	9.50E+03	0.00 50.0 50.0	500001110	
113	5	11	54.00	4.800E+04	1.59E+04	1.14E+05	0.00 1.0 1.0	500001120	
114	1	11	63.20	2.600E+04	1.14E+04	1.02E+05	0.00 1.0 1.0	500001130	
115	12	13	56.3	1.000E+04	4.70E+03	5.80E+04	0.00 1.0 1.0	500001140	
116	13	14	40.7	4.800E+03	2.00E+03	2.10E+04	0.00 1.0 1.0	500001150	
117	14	15	20.	2.700E+03	1.20E+03	8.00E+03	0.00 1.0 1.0	500001160	
118	1	12	8.0	2.208E+02	7.32E+02	1.00E+02	0.00 1.0 1.0	400001170	
119	1	14	8.0	2.208E+02	7.32E+02	1.00E+02	0.00 1.0 1.0	400001180	
120	2	11	0.01	150.0	239.E+00	239.E+00	0.00 1.0 1.0	100001190	
121	3	11	0.01	150.0	239.E+00	239.E+00	0.00 1.0 1.0	100001200	
122	1	2	0.01	5.	32.5E+00	32.5E+00	0.00 1.0 1.0	100001210	
123	6	12	40.7	4.800E+03	2.00E+03	2.10E+04	0.00 1.0 1.0	500001220	
124	9	14	40.7	4.800E+03	2.00E+03	2.10E+04	0.00 1.0 1.0	500001230	
125	12	0	40.7	4.800E+03	2.00E+03	2.10E+04	0.00 1.0 1.0	500001240	
126	2	20	10.	1.0	1.0	1.0	0.00 1.0 1.0	900001250	
127	2	21	10.	1.0	1.0	1.0	0.00 1.0 1.0	10000001260	
128	15	16	20.				0.00 1.0 1.0	500001270	
129	2	15	2	20.			0.00 1.0 1.0	500001280	
130	15	0	20.	2.700E+03	1.20E+03	8.00E+03	0.00 1.0 1.0	500001290	
131	2	15	0	20.	2.700E+03	1.20E+03	8.00E+03	0.00 1.0 1.0	500001300
132	BEAM END FIXITY CARDS: NPIN CARDS							00001310	
133	1	2	0	0	1	1	0. 0. 0.0088	1.15 00001320	
134	2	3	0	0	1	1	0. 0. 1.25	1.25 00001330	
135	3	4	0	0	1	1	0. 0. 1.1	1.1 00001340	
136	4	5	0	0	1	1	0. 0. 1.15	1.15 00001350	
137	5	6	0	0	1	1	0. 0. 1.25	1.25 00001360	
138	6	7	0	0	1	1	0. 0. 1.25	1.25 00001370	
139	7	8	0	0	1	1	0. 0. 1.15	1.15 00001380	
140	8	9	0	0	1	1	0. 0. 1.0	1.0 00001390	
141	6	12	0	0	1	1	0. 0. 0.	0. 00001400	
142	9	14	0	1	0	1	0. 0. 0.	0. 00001410	
143	UNSYM BEAM DATA: NUB CARDS							00001420	
144	15	16	1	.08				00001430	
145	2	15	2	-1	.08			00001440	
146	15	0	1	.3				00001450	
147	2	15	0	-1	.3			00001460	
148	OLEO BEAM CARDS:							00001470	
149	1.		1					00001480	
150	2	11	18	20.982	10855.	739.	1.4 20.	00001490	
151	1	2	19	16.965	3420.	289.	1.4 16.	00001500	
152	2	11	18	4.0	0.	.1E06	.1E06 5000.	1 00001510	

FIGURE 2-8. ECHO OF THE INPUT DATA (SHEET 3 OF 9)

ECHO OF THE INPUT DATA IN CARD IMAGE FORMAT

	1	2	3	4	5	6	7	8
CARD NO.	1234567890123456789012345678901234567890123456789012345678901234567890							
153	1	2	19	3.4	0.	50.E03	50.E03	500.
154			45					00001520
155	-0.2		352.7					00001530
156	-0.0964		352.7					00001540
157	-0.0376		10.24					00001550
158	0.124		23.62					00001560
159	0.341		22.21					00001570
160	0.607		17.90					00001580
161	0.953		8.24					00001590
162	1.46		3.38					00001600
163	2.17		2.13					00001610
164	3.07		1.25					00001620
165	4.13		1.56					00001630
166	5.21		1.79					00001640
167	6.20		2.46					00001650
168	7.05		3.58					00001660
169	7.72		6.26					00001670
170	8.20		13.47					00001680
171	8.53		31.50					00001690
172	8.74		62.40					00001700
173	8.91		64.06					00001710
174	9.12		34.22					00001720
175	9.41		16.03					00001730
176	9.83		8.42					00001740
177	10.39		5.24					00001750
178	11.08		3.68					00001760
179	11.87		2.93					00001770
180	12.71		2.77					00001780
181	13.54		3.38					00001790
182	14.27		4.93					00001800
183	14.83		9.33					00001810
184	15.21		25.53					00001820
185	15.40		153.79					00001830
186	15.4518		1000.					00001840
187	15.4539		1000.					00001850
188	15.4581		1000.					00001860
189	15.494		403.85					00001870
190	15.61		67.70					00001880
191	15.84		22.15					00001890
192	16.18		9.93					00001900
193	16.65		5.31					00001910
194	17.21		3.02					00001920
195	17.82		2.07					00001930
196	18.39		0.92					00001940
197	18.82		0.					00001950
198	18.97		10.					00001960
199	22.		10.					00001970
200	DAMPC CARD							00001980
201	.05							00001990
202	NONLINEAR BEAM DATA: NLB + CARDS							00002000
203	3 11 18 1 7 2.0							00002010
								00002020

FIGURE 2-8. ECHO OF THE INPUT DATA (SHEET 4 OF 9)

ECHO OF THE INPUT DATA IN CARD IMAGE FORMAT

CARD NO.	1	2	3	4	5	6	7	8
204	DRI CARD:							
205	2	21						
206	POS.FORCE CUTOFF:NFBM CARDS							
207	2	11	18	428000	1.E10	1.0E10	1.E10	1.E10
208	1	2	19	130000	1.E10	78000	1.E10	1.E10
209	NEG.FORCE CUTOFF:NFBM CARDS							
210	2	11	18	428000	1.E10	1.0E10	1.E10	1.E10
211	1	2	19	130000	1.E10	78000	1.E10	1.E10
212	LOAD INTERACTION SIGN CONVENTIONS(NSCV CARDS):							
213	1	2	-3	4	5	6		
214	LOAD INTERACTION DATA(NLIC+ CARDS):							
215	1	3	5	1	0	300.	1000.	
216						166000.	20.8E+06	-166000.
217	1	1	199000.	45.6	E+06		-20.8E+06	
218	2	3	5	1	0	300.	1000.	
219						166000.	20.8E+06	-166000.
220	1	1	199000.	45.6	E+06		-20.8E+06	
221	2	3	5	2	0	400.	1000.	
222						210000.	23.8E+06	-210000.
223	1	1	185000.	60.8	E+06		-23.8E+06	
224	1	1	674300.	25.4	E+06			
225	3	3	5	2	0	480.	1000.	
226								
227	1	1	195000.	130.3	E+06			
228	1	1	545300.	28.9	E+06			
229	3	3	5	2	0	540.	1000.	
230								
231	1	1	199000.	137.3	E+06			
232	1	1	11365380.	35.3	E+06			
233	3	3	5	2	0	620.	1000.	
234						274000.	45.0E+06	-274000.
235	1	1	286000.	185.6	E+06		-45.0E+06	
236	1	1	384400.	79.7	E+06			
237	4	3	5	2	0	620.	1000.	
238						274000.	45.0E+06	-274000.
239	1	1	286000.	185.6	E+06		-45.0E+06	
240	1	1	384400.	79.7	E+06			
241	5	3	5	2	1	960.	1000.	
242						288000.	-288000.	
243	1	0-5.2317E06	71.5E+06					
244	1	1	474500.	152.8E+06				
245	6	3	5	2	1	960.	1000.	
246						288000.	-288000.	
247	1	0-5.2317E06	71.5E+06					
248	1	1	474500.	152.8E+06				
249	6	3	5	2	1	1000.	1000.	
250						254000.	74.0E+06	-254000.
251	1	1	301000.	228.7E+06				
252	1	11.3581E	06	84.2E+06				
253	7	3	5	3	1	1080.	1000.	
254								

FIGURE 2-8. ECHO OF THE INPUT DATA (SHEET 5 OF 9)

ECHO OF THE INPUT DATA IN CARD IMAGE FORMAT

	1	2	3	4	5	6	7	8
CARD NO.	12345678901234567890123456789012345678901234567890123456789012345678901234567890							
255	0	1	210000.	-555.88E06				00002540
256	1	1	327700.	107.75E06				00002550
257	1	1	1.5738E06	64.0 E06				00002560
258	7	3	5	3	1	1160.	1000.	00002570
259								00002580
260	0	1	239000.	-265.64E06				00002590
261	1	1	372214.	83.5E 06				00002600
262	1	1	804840.	49.9E 06				00002610
263	8	3	5	3	1	1240.	1000.	00002620
264						35.0 E 06	-35.0E06	00002630
265	0	1	198000.	-217.32E06				00002640
266	1	1	409460.	50.5E 06				00002650
267	1	1	965217.	37.0E 06				00002660
268	8	3	5	2	1	1320.	1000.	00002670
269						27.2 E 06	-27.2E06	00002680
270	0	1	148000.	-91.818E06				00002690
271	1	1	662500.	31.8E 06				00002700
272	9	3	5	3	1	1400.	1000.	00002710
273								00002720
274	0	1	123500.	-54.998E06				00002730
275	1	1	350720.	24.2E 06				00002740
276	1	1	914520.	18.9E 06				00002750
277	NONZERO ANGULAR MOMENTA (NHI CARDS):							
278	16		.1	E06				00002770
279	17		.1	E06				00002780
280	NONZERO MASS ORIENTATION ANGLES (NPH CARDS):							
281	16		-.0872665	.0349066	.05236			00002790
282	17		-.0872665	.0349066	.05236			00002800
283	FORCE TIME HISTORY DATA: NACC + CARDS							
284	1	3	2	1				00002820
285	2	3	2	1				00002830
286	3	3	2	1				00002840
287	4	3	2	1				00002850
288	5	3	2	1				00002860
289	6	3	2	1				00002870
290	7	3	2	1				00002880
291	8	3	2	1				00002890
292	9	3	2	1				00002900
293	10	3	2	1				00002910
294	11	3	2	1				00002920
295	12	3	2	1				00002930
296	13	3	2	1				00002940
297	14	3	2	1				00002950
298	15	3	2	1				00002960
299	16	3	2	1				00002970
300	17	3	2	1				00002980
301	18	3	2	1				00002990
302	19	3	2	1				00003000
303	0.		-95.					00003010
304	1.		-95.					00003020
305	0.		-624.5					00003030

FIGURE 2-8. ECHO OF THE INPUT DATA (SHEET 6 OF 9)

ECHO OF THE INPUT DATA IN CARD IMAGE FORMAT

CARD NO.	1	2	3	4	5	6	7	8
306	1.	-624.5						00003050
307	0.	-1861.						00003060
308	1.	-1861.						00003070
309	0.	-4715.						00003080
310	1.	-4715.						00003090
311	0.	-7901.						00003100
312	1.	-7901.						00003110
313	0.	-1991.						00003120
314	1.	-1991.						00003130
315	0.	-2316.						00003140
316	1.	-2316.						00003150
317	0.	-785.4						00003160
318	1.	-785.4						00003170
319	0.	-450.						00003180
320	1.	-450.0						00003190
321	0.	17445.6						00003200
322	1.	17445.6						00003210
323	0.	-15419.2						00003220
324	1.	-15419.2						00003230
325	0.	-28188.2						00003240
326	1.	-28188.2						00003250
327	0.	-21394.1						00003260
328	1.	-21394.1						00003270
329	0.	-17818.8						00003280
330	1.	-17818.8						00003290
331	0.	-6240.9						00003300
332	1.	-6240.9						00003310
333	0.	-270.8						00003320
334	1.	-270.8						00003330
335	0.	-258.3						00003340
336	1.	-258.3						00003350
337	0.	0.						00003360
338	1.	0.						00003370
339	0.	0.						00003380
340	1.	0.						00003390
341	BEAM LOAD PLOT PARAMETERS: NBFP CARDS							00003400
342	3	1	1	1	0			00003410
343	7	1	1	1	1			00003420
344	11	1	1	1	0			00003430
345	11	1	1	1	1			00003440
346	12	1	1	1	1			00003450
347	14	1	1	1	0			00003460
348	END							00003470
349	\$TITLE =LT.SAMPLE.DATA							1
350	\$\$SUBTITLE=21 MASS/28 BEAM TEST CASE ONLY-NOT VALID AIRPLANE MODEL							2
351	\$LABEL =INITIAL CONDITION STATIC SOLUTION							3
352	\$DISPLACEMENTS							4
353	\$REAL OUTPUT							5
354	\$SUBCASE ID =							6
355	100	G	-3.089143E-02	0.0	-9.927106E-01			7
356	-CONT-		0.0	-2.240265E-03	0.0			8

FIGURE 2-8. ECHO OF THE INPUT DATA (SHEET 7 OF 9)

ECHO OF THE INPUT DATA IN CARD IMAGE FORMAT

CARD NO.	1	2	3	4	5	6	7	8
357	200	G	-2.848941E-02	0.0		-7.668377E-01		9
358	-CONT-		0.0	-2.228401E-03		0.0		10
359	201	G	1.302763E-01	0.0		-8.132805E-01		11
360	-CONT-		0.0	-2.228401E-03		0.0		12
361	300	G	-7.956207E-03	0.0		-4.223564E-01		13
362	-CONT-		0.0	-2.016658E-03		0.0		14
363	400	G	-3.881566E-03	0.0		-1.467094E-01		15
364	-CONT-		0.0	-1.310210E-03		0.0		16
365	500	G	0.0	0.0		0.0		17
366	-CONT-		0.0	0.0		0.0		18
367	501	G	0.0	0.0		0.0		19
368	-CONT-		0.0	0.0		0.0		20
369	600	G	3.900044E-04	0.0		-1.395651E-01		21
370	-CONT-		0.0	1.905726E-03		0.0		22
371	700	G	-1.741045E-02	0.0		-3.224223E-01		23
372	-CONT-		0.0	2.646158E-03		0.0		24
373	800	G	1.960037E-02	0.0		-8.574680E-01		25
374	-CONT-		0.0	3.925510E-03		0.0		26
375	900	G	1.623369E-01	0.0		-1.646019E+00		27
376	-CONT-		0.0	5.791210E-03		0.0		28
377	1000	G	4.121330E-01	0.0		-2.947555E+00		29
378	-CONT-		0.0	6.380443E-03		0.0		30
379	1100	G	-2.376708E-02	-6.204829E-02		4.549811E-01		31
380	-CONT-		-6.692741E-03	-2.201437E-03		-5.605556E-04		32
381	1101	G	-1.923054E-02	-6.048076E-02		3.946611E-01		33
382	-CONT-		-6.692741E-03	-2.201437E-03		-5.605556E-04		34
383	1102	G	-1.296112E-02	-1.657883E-01		7.333756E-01		35
384	-CONT-		-6.692741E-03	-2.201437E-03		-5.605556E-04		36
385	1103	G	-1.296112E-02	-1.657883E-01		7.333756E-01		37
386	-CONT-		-6.692741E-03	-2.201437E-03		-5.605556E-04		38
387	1199	G	-9.159952E-02	0.0		5.671605E-01		39
388	-CONT-		0.0	-6.671570E-03		0.0		40
389	1200	G	-2.163103E-01	4.138300E-02		2.341778E+00		41
390	-CONT-		-1.306025E-02	-6.671570E-03		-9.325834E-04		42
391	1201	G	-2.439489E-01	3.842940E-02		2.721848E+00		43
392	-CONT-		-1.306025E-02	-6.671570E-03		-9.325834E-04		44
393	1300	G	-6.008096E-01	3.054580E-01		6.170235E+00		45
394	-CONT-		-2.241265E-02	-1.032134E-02		-1.681539E-03		46
395	1400	G	-1.368592E+00	6.399863E-01		1.084585E+01		47
396	-CONT-		-2.562700E-02	-7.394243E-03		-5.296096E-03		48
397	1401	G	-1.022668E+00	2.900483E-01		9.660551E+00		49
398	-CONT-		-2.562700E-02	-7.394243E-03		-5.296096E-03		50
399	1498	G	-6.724822E-01	0.0		8.267696E+00		51
400	-CONT-		0.0	-9.067804E-03		0.0		52
401	1499	G	-6.724822E-01	0.0		8.267696E+00		53
402	-CONT-		0.0	-9.067804E-03		0.0		54
403	1500	G	-2.495207E+00	4.342729E-01		1.459589E+01		55
404	-CONT-		-1.709940E-02	-9.067804E-03		-4.925180E-03		56
405	1501	G	-2.554651E+00	3.717276E-01		1.491743E+01		57
406	-CONT-		-1.709940E-02	-9.067804E-03		-4.925180E-03		58
407	1502	G	-2.495207E+00	4.342729E-01		1.459589E+01		59

FIGURE 2-8. ECHO OF THE INPUT DATA (SHEET 8 OF 9)

ECHO OF THE INPUT DATA IN CARD IMAGE FORMAT

CARD NO.	1	2	3	4	5	6	7	8
408	-CONT-		-1.709940E-02	-9.067804E-03	-4.925180E-03			60
409	1600	G	7.919735E-02	-2.893812E-01	1.937819E+00			61
410	-CONT-		-1.295901E-02	-9.379078E-03	-1.573280E-03			62
411	1601	G	-2.385548E-01	1.247810E-01	2.086104E+00			63
412	-CONT-		-1.295901E-02	-9.379078E-03	-1.573280E-03			64
413	1602	G	7.919735E-02	-2.893812E-01	1.937819E+00			65
414	-CONT-		-1.295901E-02	-9.379078E-03	-1.573280E-03			66
415	1700	G	-6.952552E-01	-3.464461E-02	8.834676E+00			67
416	-CONT-		-2.537085E-02	-9.936552E-03	-5.952675E-03			68
417	1701	G	-1.014152E+00	6.997874E-01	8.967885E+00			69
418	-CONT-		-2.537085E-02	-9.936552E-03	-5.952675E-03			70
419	1800	G	1.832870E-01	-7.628592E-01	6.225001E-01			71
420	-CONT-		-6.689243E-03	-2.204068E-03	-5.605288E-04			72
421	1900	G	2.696309E-01	0.0	-8.798568E-01			73
422	-CONT-		0.0	-2.223161E-03	0.0			74
423	2000	G	-9.809875E-02	0.0	-8.621072E-01			75
424	-CONT-		0.0	-4.137885E-03	0.0			76
425	2100	G	-7.305723E-02	0.0	-7.669372E-01			77
426	-CONT-		0.0	-2.228401E-03	0.0			78

FIGURE 2-8. ECHO OF THE INPUT DATA (SHEET 9 OF 9)

STRAIN FORCES	TOTAL FORCES	BEAM DEFLECTIONS	EXT. SPRING DATA	ENERGY DATA	STRESS DATA	ACCEL DATA	IMPULSE DATA
1	1	1	1	1	0	1	0

FIGURE 2-9. FORMATTED PRINTOUT OF INPUT DATA (SHEET 1 OF 16)

NO. MASS POSITION PLOTS

VEHICLE INITIAL CONDITIONS

VEHICLE TRANSLATIONAL VELOCITIES IN GROUND AXES (IN/SEC)
VEHICLE ROTATIONAL VELOCITIES IN VEHICLE AXES (RAD/SEC)
EULER ANGLES OF VEHICLE RELATIVE TO GROUND (RADIAN)

XGDOT	YGDOT	ZGDOT
P'	Q'	R'
PHI'	THETA'	PSI'
3.140000 03	0.0	3.000000 02
0.0	1.000000-01	0.0
0.0	1.745000-02	0.0

INITIAL MASS POINT DEFLECTIONS

I	DXAPI(I)	DYAPI(I)	DZAPI(I)	DPHAPI(I)	DTHAPI(I)	DPSAPI(I)	I
1	3.089143D-02	0.0	9.927104D-01	0.0	-2.240265D-03	0.0	1
2	2.848941D-02	0.0	7.668377D-01	0.0	-2.228401D-03	0.0	2
3	7.956207D-03	0.0	4.223564D-01	0.0	-2.016658D-03	0.0	3
4	3.881566D-03	0.0	1.467094D-01	0.0	-1.310210D-03	0.0	4
5	0.0	0.0	0.0	0.0	0.0	0.0	5
6	3.900044D-04	0.0	1.395651D-01	0.0	1.905726D-03	0.0	6
7	1.741045D-02	0.0	3.224233D-01	0.0	2.646158D-03	0.0	7
8	-1.960037D-02	0.0	8.574600D-01	0.0	3.925510D-03	0.0	8
9	-1.623369D-01	0.0	1.646019D 00	0.0	5.791210D-03	0.0	9
10	-4.121330D-01	0.0	2.947555D 00	0.0	6.380443D-03	0.0	10
11	2.376708D-02	-6.204829D-02	-4.549811D-01	6.692741D-03	-2.201437D-03	5.605556D-04	11
12	2.183183D-01	4.138100D-02	-2.361778D 00	1.306025D-02	-6.671570D-03	9.325834D-04	12
13	6.008096D-01	3.054580D-01	-6.170235D 00	2.24265D-02	-1.032134D-02	1.681539D-03	13
14	1.368592D 00	6.399863D-01	-1.084585D 01	2.562700D-02	-7.394244D-03	5.296096D-03	14
15	2.495207D 00	4.342729D-01	-1.459589D 01	1.709940D-02	-9.067804D-03	4.925180D-03	15
16	-7.919735D-02	-2.893812D-01	-1.937819D 00	1.295901D-02	-9.379078D-03	1.573280D-03	16
17	6.952552D-01	-3.464641D-02	-8.834676D 00	2.537085D-02	-9.936552D-03	5.952675D-03	17
18	-1.832870D-01	-7.628592D-01	-6.225001D-01	6.689243D-03	-2.204068D-03	5.605288D-04	18
19	-2.696390D-01	0.0	8.798568D-01	0.0	-2.223161D-03	0.0	19
20	9.809875D-02	0.0	8.621072D-01	0.0	-4.137885D-03	0.0	20
21	7.305723D-02	0.0	7.669372D-01	0.0	-2.228401D-03	0.0	21

INITIAL NODE POINT DEFLECTIONS

I	M	DXNPAP	DYNPAP	DZNPAP
5	1	0.0	0.0	0.0
11	1	1.923054D-02	-6.048076D-02	-3.946611D-01
11	2	1.296112D-02	-1.657883D-01	-7.333756D-01
11	3	1.296112D-02	-1.657883D-01	-7.333756D-01
12	1	2.439489D-01	3.842940D-02	-2.721848D 00
14	1	1.022668D 00	2.900483D-01	-9.660551D 00
15	1	2.554651D 00	3.717276D-01	-1.491743D 01
15	2	2.495207D 00	4.342729D-01	-1.459589D 01
16	1	2.585548D-01	1.247610D-01	-2.086104D 00
16	2	-7.919735D-02	-2.893812D-01	-1.937819D 00
17	1	1.014152D 00	6.997874D-01	-8.967885D 00

FIGURE 2-9. FORMATTED PRINTOUT OF INPUT DATA (SHEET 2 OF 16)

2 1 -1.3027630-01 0.0 8.1328050-01

GENERALIZED SURFACE DATA

BETA = 0.0 DEGREES
XGIN = 0.0
ZGIN = 0.0

MASS DATA

WEIGHTS		MASS COORDINATES F.S.B.L.,M.L.				MASS MOMENTS OF INERTIA (LB-IN-SEC**2)			
I	M	X''	Y''	Z''	IX	IY	IZ	I	
1	1.585000 03	1.989690 02	0.0	2.190070 02	1.151400 04	4.000000 04	1.500000 04	1	
2	9.064500 03	2.999720 02	0.0	2.179350 02	8.908000 04	3.000000 05	9.900000 04	2	
3	1.531810 04	4.599920 02	0.0	2.082780 02	1.627800 05	9.693500 04	1.030900 05	3	
4	1.309600 04	6.199960 02	0.0	2.058530 02	1.962700 05	6.671500 04	7.938900 04	4	
5	2.175260 04	8.200000 02	0.0	2.002000 02	4.910600 05	1.256700 05	1.465100 05	5	
6	7.901500 03	9.600000 02	0.0	2.122600 02	8.138300 04	1.200000 05	2.000000 05	6	
7	9.190700 03	1.039980 03	0.0	2.075780 02	8.753600 04	1.400000 05	2.000000 05	7	
8	9.938600 03	1.200020 03	0.0	2.242430 02	8.807800 04	1.800000 05	3.000000 05	8	
9	5.702000 03	1.360060 03	0.0	2.583540 02	9.624900 04	4.178600 04	2.603900 04	9	
10	6.175200 03	1.570410 03	0.0	2.993520 02	2.153000 05	1.079800 05	1.586300 05	10	
11	9.670600 03	8.012760 02	1.183620 02	1.887520 02	1.521300 04	1.385800 05	3.600000 05	11	
12	1.004560 04	8.520820 02	2.717590 02	2.056420 02	1.951000 04	1.226300 05	3.000000 05	12	
13	5.284500 03	9.428990 02	4.303950 02	2.260700 02	7.271500 03	5.261900 04	1.100000 05	13	
14	3.759000 03	1.044430 03	5.828600 02	2.543460 02	4.408300 03	2.582300 04	6.000000 04	14	
15	1.542300 03	1.110100 03	7.401660 02	2.696960 02	3.651560 03	9.013700 03	1.800000 04	15	
16	5.400000 03	7.190790 02	9.021050 02	1.677380 02	3.712000 03	2.458820 04	2.817800 04	16	
17	5.151000 03	9.021050 02	5.516350 02	1.969350 02	2.400000 01	3.000000 02	5.000000 02	17	
18	1.922000 03	8.871830 02	1.323630 02	9.132250 01	1.000000 03	1.000000 03	1.000000 03	18	
19	2.380000 02	2.792700 02	0.0	8.412010 01	2.400000 01	3.000000 02	5.000000 02	19	
20	1.000000 03	2.999020 02	0.0	2.378380 02	1.000000 03	1.000000 03	1.000000 03	20	
21	1.000000 03	2.999270 02	0.0	2.379330 02	1.000000 03	1.000000 03	1.000000 03	21	

NODE POINT DATA

MASS N.P.		NODE POINT COORDINATES F.S.B.L.,M.L.			
I	M	X''	Y''	Z''	
5	1	7.751000 02	4.800000 01	1.810000 02	
11	1	7.738810 02	1.183600 02	1.866950 02	
11	2	8.869870 02	1.317660 02	1.804330 02	
11	3	8.869870 02	1.317660 02	1.804330 02	
12	1	8.115560 02	3.215620 02	2.023220 02	
14	1	9.934770 02	5.513100 02	2.301610 02	
15	1	1.145450 03	7.402280 02	2.762170 02	
15	2	1.110100 03	7.401660 02	2.696960 02	
16	1	7.354610 02	3.214750 02	2.016860 02	
16	2	7.190790 02	3.218890 02	1.677380 02	
17	1	9.173860 02	5.509000 02	2.294680 02	
2	1	2.791300 02	0.0	1.466870 02	

EXTERNAL SPRING DATA

FIGURE 2-9. FORMATTED PRINTOUT OF INPUT DATA (SHEET 3 OF 16)

SPRING		FREE LENGTH		FRICTION COEFFICIENT		BOTTOMING SPRING		PLOWING FORCE		GROUND FLEXIBILITY	
I	K	M	LB/IN (IKM)	MU (IKM)	KE (IKM)	FORCE (IKM)	GFLEX (IKM)				
1	3	0	7.00000 01	3.50000-01	1.75000 05	0.0	0.0				
2	3	0	8.27000 01	3.50000-01	3.00000 05	0.0	0.0				
3	3	0	7.27000 01	3.50000-01	3.00000 05	0.0	0.0				
4	3	0	7.00000 01	3.50000-01	3.00000 05	0.0	0.0				
5	3	0	6.42000 01	3.50000-01	3.00000 05	0.0	0.0				
6	3	0	7.64000 01	3.50000-01	3.00000 05	0.0	0.0				
7	3	0	6.94000 01	3.50000-01	3.00000 05	0.0	0.0				
8	3	0	6.91000 01	3.50000-01	3.00000 05	0.0	0.0				
9	3	0	6.40000 01	3.50000-01	3.00000 05	0.0	0.0				
10	3	0	8.20000 01	3.50000-01	3.00000 05	0.0	0.0				
11	3	0	2.80000 01	3.50000-01	1.00000 05	0.0	0.0				
12	3	0	1.40000 01	3.50000-01	1.00000 05	0.0	0.0				
13	3	0	1.10000 01	3.50000-01	1.00000 05	0.0	0.0				
14	3	0	7.00000 00	3.50000-01	1.00000 05	0.0	0.0				
15	3	0	3.00000 00	3.50000-01	1.00000 05	0.0	0.0				
16	3	0	2.98000 01	3.50000-01	2.72000 05	0.0	0.0				
17	3	0	2.80000 01	3.50000-01	2.72000 05	0.0	0.0				
18	3	0	1.96500 01	3.00000-01	1.00000 05	0.0	0.0				
19	3	0	1.64500 01	3.00000-01	1.00000 05	0.0	0.0				

SPRING		DEFLECTION COORDINATES		SPRING AXIAL FORCES	
I	K	M	SA (IKM)	SB (IKM)	SC (IKM)
1	3	0	1.50000 00	1.60000 00	1.00000 01
2	3	0	1.50000 00	1.60000 00	1.00000 01
3	3	0	1.00000 00	1.00000 01	2.10000 01
4	3	0	1.00000 00	2.00000 00	3.00000 00
5	3	0	1.00000 00	2.00000 00	3.00000 00
6	3	0	1.00000 00	2.00000 00	3.00000 00
7	3	0	1.00000 00	1.00000 01	2.10000 01
8	3	0	1.00000 00	1.00000 01	2.10000 01
9	3	0	1.00000 00	2.00000 00	3.00000 00
10	3	0	1.00000 00	2.00000 00	3.00000 00
11	3	0	1.00000 00	2.00000 00	3.00000 00
12	3	0	1.50000 00	2.00000 00	3.00000 00
13	3	0	1.50000 00	2.00000 00	3.00000 00
14	3	0	1.50000 00	2.00000 00	3.00000 00
15	3	0	1.50000 00	2.00000 00	3.00000 00
16	3	0	1.00000 00	2.00000 00	3.00000 00
17	3	0	1.00000 00	2.00000 00	3.00000 00
18	3	0	2.00000 00	8.05000 00	8.05000 00
19	3	0	2.00000 00	5.75000 00	5.75000 00

MATERIAL PROPERTIES		TENSION STRESS		COMPRESSION STRESS		SHEAR STRESS	
MATERIAL NO.	MODULUS OF ELASTICITY	MODULUS OF RIGIDITY	TENSION STRESS	COMPRESSION STRESS	SHEAR STRESS		
1	3.00000 07	1.10000 07	75000.	75000.	37500.		
2	3.00000 07	1.10000 07	205000.	205000.	80000.		
3	2.80000 07	1.25000 07	70000.	46000.	36000.		
4	1.05000 07	4.00000 06	47000.	39000.	22000.		
5	1.00000 07	3.80000 06	35000.	34000.	17000.		
6	1.00000 07	3.80000 06	16000.	16000.	17000.		

MATERIAL PROPERTIES		CRIT. DAMP		CDAMP (IKM)	
MATERIAL NO.	MODULUS OF ELASTICITY	CRIT. DAMP	CDAMP (IKM)		
1	3.00000 07	0.0	0.0		
2	3.00000 07	0.0	0.0		
3	2.80000 07	0.0	0.0		
4	1.05000 07	0.0	0.0		
5	1.00000 07	0.0	0.0		
6	1.00000 07	0.0	0.0		
7	1.00000 07	0.0	0.0		
8	1.00000 07	0.0	0.0		
9	1.00000 07	0.0	0.0		
10	1.00000 07	0.0	0.0		
11	1.00000 07	0.0	0.0		
12	1.00000 07	0.0	0.0		
13	1.00000 07	0.0	0.0		
14	1.00000 07	0.0	0.0		
15	1.00000 07	0.0	0.0		
16	1.00000 07	0.0	0.0		
17	1.00000 07	0.0	0.0		
18	2.00000 00	2.00000-02	1.573250 01		
19	2.00000 00	2.00000-02	2.820990 00		

FIGURE 2-9. FORMATTED PRINTOUT OF INPUT DATA (SHEET 4 OF 16)

7	1.00000 06	4.00000 05	16000.	10000.	17000.
8	1.00000 06	0.0	16000.	10000.	17000.
9	1.00000 06	4.00000 05	16000.	10000.	17000.
10	1.00000 06	4.00000 05	16000.	10000.	17000.

INTERNAL BEAM DATA

BEAM		AREA		MOMENTS OF INERTIA				DISTANCES FROM NEUTRAL AXIS TO EXTREME FIBRES				DAMPING RATIO		P-CODES		V BEAM	
I J	I J	M	M	A	IYY	IZZ	JX	Z1	Z2	XIQ	XIQ	CBAR	MC	I J	I J	B	NO.
1	1	2	0	3.2000	01	6.2000	04	9.9000	04	9.6000	01	9.6000	01	0	1	0	1
2	2	3	0	3.6000	01	7.7000	04	4.3000	04	1.2000	05	9.9000	01	9.9000	01	0	2
3	3	4	0	3.8000	01	8.6000	04	4.3000	04	1.2000	05	5.6000	01	5.6000	01	0	3
4	4	5	0	5.9000	01	1.3600	05	4.6500	04	1.8250	05	5.6000	01	5.6000	01	0	4
5	5	6	0	5.9000	01	1.1600	05	4.6500	04	1.8250	05	6.6000	01	6.6000	01	0	5
6	6	7	0	5.7000	01	1.3600	05	5.7000	04	1.9300	05	8.8000	01	8.8000	01	0	6
7	7	8	0	4.8000	01	1.1400	05	6.2000	04	1.7600	05	9.1000	01	9.1000	01	0	7
8	8	9	0	3.7000	01	5.6000	04	3.3500	04	8.9500	04	5.1000	01	5.1000	01	0	8
9	9	10	0	2.5000	01	9.0000	04	1.5900	04	9.5000	03	9.5000	01	9.5000	01	0	9
10	10	11	0	1.54000	01	1.5900	04	1.1400	05	4.8000	04	1.0000	00	1.0000	00	0	10
11	11	12	1	0.63200	01	1.1400	04	1.0200	05	2.6000	04	1.0000	00	1.0000	00	0	11
12	12	13	0	0.5360	01	4.7000	03	5.8000	04	1.0000	04	1.0000	00	1.0000	00	0	12
13	13	14	0	0.4700	01	2.0000	03	2.1000	04	4.8000	03	1.0000	00	1.0000	00	0	13
14	14	15	0	1.2000	01	2.0000	03	8.0000	03	2.7000	03	1.0000	00	1.0000	00	0	14
15	15	16	1	1.80000	00	7.3200	02	1.0000	02	2.2080	02	1.0000	00	1.0000	00	0	15
16	16	17	1	1.80000	00	7.3200	02	1.0000	02	2.2080	02	1.0000	00	1.0000	00	0	16
17	17	18	2	0.10000	-02	2.3900	02	2.3900	02	1.5000	02	1.0000	00	1.0000	00	0	17
18	18	19	3	0.10000	-02	2.3900	02	2.3900	02	1.5000	02	1.0000	00	1.0000	00	0	18
19	19	20	1	0.10000	-02	2.3900	02	2.3900	02	1.5000	02	1.0000	00	1.0000	00	0	19
20	20	21	0	4.0700	01	2.0000	03	2.2500	01	5.0000	00	1.0000	00	1.0000	00	0	20
21	21	22	0	4.0700	01	2.0000	03	2.2500	01	5.0000	00	1.0000	00	1.0000	00	0	21
22	22	23	0	4.0700	01	2.0000	03	2.2500	01	5.0000	00	1.0000	00	1.0000	00	0	22
23	23	24	0	2.0360	-01	1.0000	00	1.0000	00	1.0000	00	1.0000	00	1.0000	00	0	23
24	24	25	0	1.3090	-01	1.0000	00	1.0000	00	1.0000	00	1.0000	00	1.0000	00	0	24
25	25	26	0	2.0000	01	0.0	0.0	0.0	0.0	0.0	0.0	1.0000	00	1.0000	00	0	25
26	26	27	0	2.0000	01	0.0	0.0	0.0	0.0	0.0	0.0	1.0000	00	1.0000	00	0	26
27	27	28	0	2.0000	01	1.2000	03	8.0000	03	2.7000	03	1.0000	00	1.0000	00	0	27
28	28	29	0	2.0000	01	1.2000	03	8.0000	03	2.7000	03	1.0000	00	1.0000	00	0	28

UNSYMMETRICAL BEAM DATA

BEAM	TENSION-COMPRESSION FLAG	DEADBAND
I J	I J	DB
25 15 16 0 0	1	8.0000-02
26 15 16 2 2	-1	8.0000-02
27 15 0 0 0	1	3.0000-01
28 15 0 2 0	-1	3.0000-01

PLASTIC HINGE AND END-FIXITY DATA

BEAM	P-CODES	SHAPE FACTORS	PLASTIC HINGE MOMENTS
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FIGURE 2-9. FORMATTED PRINTOUT OF INPUT DATA (SHEET 5 OF 16)

IJ	I	J	M	N	IVIZJYJZ	SF35	SF26	SF35J	SF26J	PLM35	PLM26	PLM35J	PLM26J
1	1	2	0	0	0	0	0	0	0	0	0	0	0
2	2	3	0	0	0	0	0	0	0	0	0	0	0
3	3	4	0	0	0	0	0	0	0	0	0	0	0
4	4	5	0	0	0	0	0	0	0	0	0	0	0
5	5	6	0	0	0	0	0	0	0	0	0	0	0
6	6	7	0	0	0	0	0	0	0	0	0	0	0
7	7	8	0	0	0	0	0	0	0	0	0	0	0
8	8	9	0	0	0	0	0	0	0	0	0	0	0
20	6	12	0	0	0	0	0	0	0	0	0	0	0
21	9	14	0	0	0	0	0	0	0	0	0	0	0

OLEO STRUT BEAM DATA

BEAM AIR CURVE PARAMETERS

IJ	I	J	M	N	EOLEO	FAO	FAA	EXPOLE	YHAX
17	11	18	2	0	2.0980	01	1.0860	04	7.3900
18	12	19	1	0	1.6970	01	3.4200	03	2.8900

BEAM DAMPING CONSTANTS, COULOMB FRICTION AND LINEAR SPRINGS (EXTENSION & COMPRESSION)

IJ	I	J	M	N	BOLEO	BROLEO	XKEXT	XKCOMP	FCOUL	MPTAB
17	11	18	2	0	4.0000	00	0.0	1.0000	05	5.0000
19	2	19	1	0	3.4000	00	0.0	5.0000	04	5.0000

OLEO METERING PIN TABLES

TABLE NO. 1

YOLEO	BH
-2.000000-01	3.527000 02
-9.640000-02	3.527000 02
-3.760000-02	1.024000 01
1.240000-01	2.562000 01
3.410000-01	2.221000 01
6.070000-01	1.790000 01
9.530000-01	8.240000 00
1.460000 00	3.380000 00
2.170000 00	2.130000 00
3.070000 00	1.250000 00
4.130000 00	1.560000 00
5.210000 00	1.790000 00
6.200000 00	2.460000 00
7.050000 00	3.580000 00
7.720000 00	6.260000 00
8.200000 00	1.347000 01
8.530000 00	3.150000 01
8.740000 00	6.240000 01
8.910000 00	6.406000 01
9.120000 00	3.422000 01
9.410000 00	1.603000 01
9.830000 00	8.420000 00
1.039000 01	5.240000 00
1.108000 01	3.680000 00
1.187000 01	2.930000 00

FIGURE 2-9. FORMATTED PRINTOUT OF INPUT DATA (SHEET 6 OF 16)

PROFILINEAR BEAM DATA

BEAM		DIRECTION		STANDARD TABLE NO.	LINEAR DEFLECTION	BOTTOMING DEFLECTION
IJ	I J	H	N	NP	LDP	LDP1
18	11 18	3	0	7	2.00000E 00	0.0

```

KR TABLE FOR I,J,M,N,L = 11 18
1 0.0 1.00000E 00
2 2.00000E 00 1.00000E 00
3 2.00200E 00 -5.00000E-01
4 6.00000E 00 -5.00000E-01
5 6.00200E 00 0.0
6 2.00000E 01 0.0
7 4.00000E 01 0.0

```

ORI ELEMENTS

21
22

NON-STANDARD MAXIMUM POS & NEG FORCES

BEAM		MAXIMUM FORCES					
I	J	1	2	3	4	5	6
1	1	0	0.0	0.0	0.0	0.0	0.0
2	2	0	0.0	0.0	0.0	0.0	0.0
3	3	0	0.0	0.0	0.0	0.0	0.0
4	4	0	0.0	0.0	0.0	0.0	0.0
5	5	0	0.0	0.0	0.0	0.0	0.0
6	6	0	0.0	0.0	0.0	0.0	0.0

FIGURE 2-9. FORMATTED PRINTOUT OF INPUT DATA (SHEET 7 OF 16)

5	5	0	0	0.0	0.0	0.0	0.0	0.0	0.0
6	7	0	0	0.0	0.0	0.0	0.0	0.0	0.0
7	8	0	0	0.0	0.0	0.0	0.0	0.0	0.0
8	9	0	0	0.0	0.0	0.0	0.0	0.0	0.0
9	10	0	0	0.0	0.0	0.0	0.0	0.0	0.0
10	5	11	0	1	0.0	0.0	0.0	0.0	0.0
11	11	12	1	0	0.0	0.0	0.0	0.0	0.0
12	12	13	0	0	0.0	0.0	0.0	0.0	0.0
13	13	14	0	0	0.0	0.0	0.0	0.0	0.0
14	14	15	0	1	0.0	0.0	0.0	0.0	0.0
15	12	16	1	1	0.0	0.0	0.0	0.0	0.0
16	14	17	1	1	0.0	0.0	0.0	0.0	0.0
17	11	18	2	0	4.28000 05	0.0	0.0	0.0	0.0
18	11	18	3	0	4.28000 05	0.0	0.0	0.0	0.0
19	2	19	1	0	1.30000 05	0.0	7.80000 04	0.0	0.0
20	6	12	0	0	1.30000 05	0.0	7.80000 04	0.0	0.0
21	9	14	0	0	0.0	0.0	0.0	0.0	0.0
22	12	0	0	0	0.0	0.0	0.0	0.0	0.0
23	2	20	0	0	0.0	0.0	0.0	0.0	0.0
24	2	21	0	0	0.0	0.0	0.0	0.0	0.0
25	15	16	0	0	0.0	0.0	0.0	0.0	0.0
26	15	16	2	2	0.0	0.0	0.0	0.0	0.0
27	15	0	0	0	0.0	0.0	0.0	0.0	0.0
28	15	0	2	0	0.0	0.0	0.0	0.0	0.0

LOAD INTERACTION CURVE SIGN CONVENTION VECTORS

SIGN CONVENTION NUMBER	CALAC LOAD NUMBER AND SIGN FOR USER LOAD NUMBER =
1	1 2 3 4 5 6
1	1 2 -3 4 5 6

LOAD INTERACTION CURVE DATA

FIGURE 2-9. FORMATTED PRINTOUT OF INPUT DATA (SHEET 8 OF 16)

CURVE NO.	BEAM LOAD NUMBER FOR			NO. OF SLOPING		SIGN CONVENTION NUMBER	INTERSECTION CURVE		LOCATION	RUPTURE RATIO				
	NO.	X AXIS	Y AXIS	INTERACTION LINES	FS		BL							
1	1	3	5	4	0		300.0000	0.0	0.0	1000.0000				
	2	3	5	4	0		300.0000	0.0	0.0	1000.0000				
	3	3	5	8	0		400.0000	0.0	0.0	1000.0000				
4	3	3	5	8	0		480.0000	0.0	0.0	1000.0000				
	5	3	5	8	0		540.0000	0.0	0.0	1000.0000				
	6	3	5	8	0		620.0000	0.0	0.0	1000.0000				
6	3	3	5	8	0		620.0000	0.0	0.0	1000.0000				
	5	3	5	6	1		960.0000	0.0	0.0	1000.0000				
	6	3	5	6	1		960.0000	0.0	0.0	1000.0000				
10	6	3	5	8	1		1000.0000	0.0	0.0	1000.0000				
	11	7	3	5	10	1	1080.0000	0.0	0.0	1000.0000				
	12	7	3	5	10	1	1160.0000	0.0	0.0	1000.0000				
13	8	3	5	10	1		1240.0000	0.0	0.0	1000.0000				
	14	8	3	5	6	1	1320.0000	0.0	0.0	1000.0000				
	9	3	5	10	1		1400.0000	0.0	0.0	1000.0000				
CURVE NO.	+X AXIS		MAXIMUM LOAD CUTOFFS:		-Y AXIS		LOAD LINE INTERCEPTS		LOAD LINE NUMBER					
			+Y AXIS	-X AXIS			X AXIS	Y AXIS						
1	1	1.66000	05	2.08000	07	-1.66000	05	-2.08000	07	1.99000	05	4.56000	07	1
										1.99000	05	-4.56000	07	2
										-1.99000	05	4.56000	07	3
										-1.99000	05	-4.56000	07	4
2	2	1.66000	05	2.08000	07	-1.66000	05	-2.08000	07	1.99000	05	4.56000	07	1
										1.99000	05	-4.56000	07	2
										-1.99000	05	4.56000	07	3
										-1.99000	05	-4.56000	07	4
3	3	2.10000	05	2.38000	07	-2.10000	05	-2.38000	07	1.85000	05	6.08000	07	1
										6.74300	05	2.54000	07	2
										1.85000	05	-6.08000	07	3
										-1.85000	05	6.08000	07	4
4										-1.85000	05	-6.08000	07	5
										6.74300	05	-2.54000	07	6
										-6.74300	05	2.54000	07	7
										-6.74300	05	-2.54000	07	8
5	4	1.00000	20	1.00000	20	1.00000	20	1.00000	20	1.95000	05	1.30300	08	1
										5.45300	05	2.89000	07	2
										1.95000	05	-1.30300	08	3
										-1.95000	05	1.30300	08	4
6										-1.95000	05	-1.30300	08	5
										5.45300	05	-2.89000	07	6
										-5.45300	05	2.89000	07	7
										-5.45300	05	-2.89000	07	8
5	5	1.00000	20	1.00000	20	1.00000	20	1.00000	20	1.99000	05	1.37300	08	1
										1.36540	06	3.53000	07	2
										1.99000	05	-1.37300	08	3
										-1.99000	05	1.37300	08	4
6										-1.99000	05	-1.37300	08	5
										1.36540	06	-3.53000	07	6
										-1.36540	06	3.53000	07	7
										-1.36540	06	-3.53000	07	8
6	6	2.74000	05	4.50000	07	-2.74000	05	-4.50000	07	2.86000	05	1.85600	08	1
										3.84400	05	7.97000	07	2
										2.86000	05	-1.85600	08	3
										-2.86000	05	1.85600	08	4
6										-2.86000	05	-1.85600	08	5
										3.84400	05	-7.97000	07	6

7	2.74000 05	4.50000 07	-2.74000 05	-4.50000 07	-3.84400 05	7.97000 07	7
					-3.84400 05	-7.97000 07	8
					2.86000 05	1.85600 08	1
					3.84400 05	7.97000 07	2
					2.86000 05	-1.85600 08	3
					-2.86000 05	1.85600 08	4
					-2.86000 05	-1.85600 08	5
					3.84400 05	7.97000 07	6
					-3.84400 05	-7.97000 07	7
8	2.88000 05	1.00000 20	-2.88000 05	1.00000 20	-3.84400 05	7.97000 07	8
					-5.23170 06	7.15000 07	1
					4.74500 05	1.52800 08	2
					-5.23170 06	-7.15000 07	3
					4.74500 05	-1.52800 08	4
					-4.74500 05	1.52800 08	5
					-4.74500 05	-1.52800 08	6
9	2.88000 05	1.00000 20	-2.88000 05	1.00000 20	-5.23170 06	7.15000 07	1
					4.74500 05	1.52800 08	2
					-5.23170 06	-7.15000 07	3
					4.74500 05	-1.52800 08	4
					-4.74500 05	1.52800 08	5
					-4.74500 05	-1.52800 08	6
10	2.54000 05	7.40000 07	-2.54000 05	-7.40000 07	3.01000 05	2.28700 08	1
					1.35810 06	8.42000 07	2
					3.01000 05	-2.28700 08	3
					-3.01000 05	2.28700 08	4
					-3.01000 05	-2.28700 08	5
					1.35810 06	8.42000 07	6
					-1.35810 06	-8.42000 07	7
11	1.00000 20	1.00000 20	1.00000 20	1.00000 20	-1.35810 06	-8.42000 07	8
					2.10000 05	-5.55830 08	1
					3.27700 05	1.07750 08	2
					1.57380 06	6.40000 07	3
					-2.10000 05	-5.55830 08	4
					3.27700 05	-1.07750 08	5
					-3.27700 05	1.07750 08	6
					-3.27700 05	-1.07750 08	7
					1.57380 06	-6.40000 07	8
					-1.57380 06	6.40000 07	9
12	1.00000 20	1.00000 20	1.00000 20	1.00000 20	-1.57380 06	-6.40000 07	10
					2.39000 05	-2.65640 08	1
					3.72210 05	8.35000 07	2
					8.04840 05	4.99000 07	3
					-2.39000 05	-2.65640 08	4
					3.72210 05	-8.35000 07	5
					-3.72210 05	8.35000 07	6
					-3.72210 05	-8.35000 07	7
					8.04840 05	-4.99000 07	8
					-8.04840 05	4.99000 07	9
13	1.00000 20	3.50000 07	1.00000 20	-3.50000 07	-8.04840 05	-4.99000 07	10
					1.98000 05	-2.17320 08	1
					4.09460 05	5.05000 07	2
					9.65220 05	3.70000 07	3
					-1.98000 05	-2.17320 08	4
					4.09460 05	-5.05000 07	5
					-4.09460 05	5.05000 07	6
					-4.09460 05	-5.05000 07	7
					9.65220 05	-3.70000 07	8
					-9.65220 05	3.70000 07	9
					-9.65220 05	-3.70000 07	10

FIGURE 2-9. FORMATTED PRINTOUT OF INPUT DATA (SHEET 10 OF 16)

14	1.00000 20	2.72000 07	1.00000 20	-2.72000 07	1.48000 05	-9.18180 07	1
					6.62500 05	3.18000 07	2
					-1.48000 05	-9.18180 07	3
					6.62500 05	3.18000 07	4
					-6.62500 05	3.18000 07	5
					-6.62500 05	3.18000 07	6
15	1.00000 20	1.00000 20	1.00000 20	1.00000 20	1.23500 05	-5.49980 07	1
					3.50720 05	2.42000 07	2
					9.14520 05	1.89000 07	3
					-1.23500 05	-5.49980 07	4
					3.50720 05	2.42000 07	5
					-3.50720 05	2.42000 07	6
					-3.50720 05	-2.42000 07	7
					9.14520 05	-1.89000 07	8
					-9.14520 05	1.89000 07	9
					-9.14520 05	-1.89000 07	10

MASSSES HAVING NONZERO ANGULAR MOMENTA (HEY,
CROSS PRODUCTS OF INERTIA (IXY,IYZ,IXZ)
OR LIFT CONSTANTS (LC)

I	LC	HEX	HEY	HEZ	IXY	IYZ	IXZ
16	0.0	1.00000 05	0.0	0.0	0.0	0.0	0.0
17	0.0	1.00000 05	0.0	0.0	0.0	0.0	0.0

I	PHIDP	THEOP	PSIDP
1	0.0	-2.240270-03	0.0
2	0.0	-2.228400-03	0.0
3	0.0	-2.016660-03	0.0
4	0.0	-1.310210-03	0.0
5	0.0	0.0	0.0
6	0.0	1.905730-03	0.0
7	0.0	2.646160-03	0.0
8	0.0	3.925510-03	0.0
9	0.0	5.791210-03	0.0
10	0.0	6.380440-03	0.0
11	6.692740-03	-2.201440-03	5.605560-04
12	1.306030-02	-6.671570-03	9.325830-04
13	2.241270-02	-1.032130-02	1.681540-03
14	2.562700-02	-7.594240-03	5.296100-03
15	1.709940-02	-9.067800-03	4.925180-03
16	-7.481290-02	2.485950-02	5.436620-02
17	-6.244490-02	2.364520-02	5.916540-02
18	6.689240-03	-2.204070-03	5.605290-04
19	0.0	-2.223160-03	0.0
20	0.0	-4.137890-03	0.0
21	0.0	-2.228400-03	0.0

ACCELERATION INPUT TABLE DATA

MASS LOCATION	DIRECTION	TYPE
1	3	1
2	2	1
3	2	1
4	3	1
5	3	1
6	3	1

FIGURE 2-9. FORMATTED PRINTOUT OF INPUT DATA (SHEET 11 OF 16)

7	3	2	1
8	3	2	1
9	3	2	1
10	3	2	1
11	3	2	1
12	3	2	1
13	3	2	1
14	3	2	1
15	3	2	1
16	3	2	1
17	3	2	1
18	3	2	1
19	3	2	1

PT	TIME	ACCEL
1	0.0	-9.500E 01
2	1.000E 00	-9.500E 01
3	0.0	-6.245E 02
4	1.000E 00	-6.245E 02
5	0.0	-1.861E 03
6	1.000E 00	-1.861E 03
7	0.0	-4.715E 03
8	1.000E 00	-4.715E 03
9	0.0	-7.901E 03
10	1.000E 00	-7.901E 03
11	0.0	-1.991E 03
12	1.000E 00	-1.991E 03
13	0.0	-2.316E 03
14	1.000E 00	-2.316E 03
15	0.0	-7.854E 02
16	1.000E 00	-7.854E 02
17	0.0	-4.500E 02
18	1.000E 00	-4.500E 02
19	0.0	1.745E 04
20	1.000E 00	1.745E 04
21	0.0	-1.542E 04
22	1.000E 00	-1.542E 04
23	0.0	-2.819E 04
24	1.000E 00	-2.819E 04
25	0.0	-2.139E 04
26	1.000E 00	-2.139E 04
27	0.0	-1.782E 04
28	1.000E 00	-1.782E 04
29	0.0	-6.241E 03
30	1.000E 00	-6.241E 03
31	0.0	-2.708E 02
32	1.000E 00	-2.708E 02
33	0.0	-2.583E 02
34	1.000E 00	-2.583E 02
35	0.0	0.0
36	1.000E 00	0.0
37	0.0	0.0
38	1.000E 00	0.0

I,J,M,N
 K-MATRIX FOR INTERNAL BEAM IJ
 1 2 0 0
 3.16806D 06 0.0 0.0 0.0 0.0

FIGURE 2-9. FORMATTED PRINTOUT OF INPUT DATA (SHEET 12 OF 16)

0.0	4.308380 06	0.0	0.0	0.0	-2.175910 08
0.0	0.0	7.219450 06	0.0	3.646120 08	0.0
0.0	0.0	0.0	3.724450 09	0.0	0.0
0.0	0.0	3.646120 08	0.0	2.455250 10	0.0
2 3 0 0	-2.175910 08	0.0	0.0	0.0	1.665230 10
2.245630 06	0.0	0.0	0.0	0.0	0.0
0.0	1.252430 06	0.0	0.0	-1.003900 08	0.0
0.0	0.0	2.242730 06	0.0	1.797680 08	0.0
0.0	0.0	0.0	2.844440 09	0.0	0.0
0.0	0.0	1.797680 08	0.0	1.921260 10	0.0
0.0	-1.003900 08	0.0	0.0	0.0	1.072910 10
3 4 0 0	0.0	0.0	0.0	0.0	0.0
2.249680 06	1.259240 06	0.0	0.0	0.0	-1.007530 08
0.0	0.0	2.518470 06	0.0	2.015060 08	0.0
0.0	0.0	0.0	3.063320 09	0.0	0.0
0.0	0.0	2.015060 08	0.0	2.149700 10	0.0
0.0	-1.007530 08	0.0	0.0	0.0	1.074850 10
4 5 0 0	0.0	0.0	0.0	0.0	0.0
2.948770 06	6.966240 05	0.0	0.0	0.0	-6.969160 07
0.0	0.0	2.037440 06	0.0	2.038290 08	0.0
0.0	0.0	0.0	3.466050 09	0.0	0.0
0.0	0.0	2.038290 08	0.0	2.718860 10	0.0
0.0	-6.969160 07	0.0	0.0	0.0	9.296110 09
5 6 0 0	0.0	0.0	0.0	0.0	0.0
4.198720 06	2.011080 06	0.0	0.0	0.0	0.0
0.0	0.0	5.016890 06	0.0	3.524840 08	-1.412980 08
0.0	0.0	0.0	4.394430 09	0.0	0.0
0.0	0.0	3.524840 08	0.0	3.302050 10	0.0
0.0	-1.412980 08	0.0	0.0	0.0	1.323670 10
6 7 0 0	0.0	0.0	0.0	0.0	0.0
7.114400 06	1.329990 07	0.0	0.0	0.0	0.0
0.0	0.0	3.173300 07	0.0	1.271210 09	-5.327870 08
0.0	0.0	0.0	9.153860 09	0.0	0.0
0.0	0.0	1.271210 09	0.0	6.789890 10	0.0
0.0	-5.327870 08	0.0	0.0	0.0	2.845760 10
7 8 0 0	0.0	0.0	0.0	0.0	0.0
2.983180 06	1.786020 06	0.0	0.0	0.0	0.0
0.0	0.0	3.283970 06	0.0	2.641990 08	-1.436870 08
0.0	0.0	0.0	4.156560 09	0.0	0.0
0.0	0.0	2.641990 08	0.0	2.834020 10	0.0
0.0	-1.436870 08	0.0	0.0	0.0	1.541310 10
8 9 0 0	0.0	0.0	0.0	0.0	0.0
2.261090 06	9.174380 05	0.0	0.0	0.0	0.0
0.0	0.0	1.533630 06	0.0	1.254800 08	-7.506370 07
0.0	0.0	0.0	2.078370 09	0.0	0.0
0.0	0.0	1.254800 08	0.0	1.368880 10	0.0
0.0	-7.506370 07	0.0	0.0	0.0	8.188830 09
9 10 0 0	0.0	0.0	0.0	0.0	0.0
1.166550 06	1.158220 05	0.0	0.0	0.0	0.0
0.0	0.0	1.097260 06	0.0	1.175760 08	-1.241080 07
0.0	0.0	0.0	1.764280 09	0.0	0.0
0.0	0.0	1.175760 08	0.0	1.679830 10	0.0

FIGURE 2-9. FORMATTED PRINTOUT OF INPUT DATA (SHEET 13 OF 16)

FIGURE 2-9. FORMATTED PRINTOUT OF INPUT DATA (SHEET 14 OF 16)

0.0	0.0	1.215840 05	0.0	5.417360 06	0.0
0.0	0.0	0.0	1.851580 07	0.0	0.0
0.0	0.0	5.417360 06	0.0	3.218380 08	0.0
0.0	-5.417360 06	0.0	0.0	0.0	3.218380 08
2 19 1 0					
4.794880 03	0.0	0.0	0.0	0.0	0.0
0.0	4.777000 04	0.0	0.0	0.0	-1.494410 06
0.0	0.0	4.777000 04	0.0	1.494410 06	0.0
0.0	0.0	0.0	8.790610 05	0.0	0.0
0.0	0.0	1.494410 06	0.0	6.233340 07	0.0
0.0	-1.494410 06	0.0	0.0	0.0	6.233340 07
6 12 0 0					
1.391540 06	0.0	0.0	0.0	0.0	0.0
0.0	1.007170 05	0.0	0.0	0.0	-1.472900 07
0.0	0.0	9.592110 03	0.0	1.402760 06	0.0
0.0	0.0	0.0	6.236280 07	0.0	0.0
0.0	0.0	1.402760 06	0.0	2.735210 08	0.0
0.0	-1.472900 07	0.0	0.0	0.0	2.871970 09
9 14 0 0					
6.140190 05	0.0	0.0	0.0	0.0	0.0
0.0	8.652920 03	0.0	0.0	0.0	-2.867780 06
0.0	0.0	8.240880 02	0.0	2.731220 05	0.0
0.0	0.0	0.0	2.751770 07	0.0	0.0
0.0	0.0	2.731220 05	0.0	1.206920 08	0.0
0.0	-2.867780 06	0.0	0.0	0.0	1.267260 09
12 0 0 0					
7.488260 05	0.0	0.0	0.0	0.0	0.0
0.0	1.569500 04	0.0	0.0	0.0	-4.265240 06
0.0	0.0	1.494760 03	0.0	4.062140 05	0.0
0.0	0.0	0.0	3.355920 07	0.0	0.0
0.0	0.0	4.062140 05	0.0	1.471890 08	0.0
0.0	-4.265240 06	0.0	0.0	0.0	1.545490 09
2 20 0 0					
1.022760 04	0.0	0.0	0.0	0.0	0.0
0.0	1.521610 03	0.0	0.0	0.0	-1.514370 04
0.0	0.0	1.521610 03	0.0	1.514370 04	0.0
0.0	0.0	0.0	2.009560 04	0.0	0.0
0.0	0.0	1.514370 04	0.0	2.009560 05	0.0
0.0	-1.514370 04	0.0	0.0	0.0	2.009560 05
2 21 0 0					
6.545600 03	0.0	0.0	0.0	0.0	0.0
0.0	1.500010 03	0.0	0.0	0.0	-1.500010 04
0.0	0.0	1.500010 03	0.0	1.500010 04	0.0
0.0	0.0	0.0	2.000000 04	0.0	0.0
0.0	0.0	1.500010 04	0.0	2.000000 05	0.0
0.0	-1.500010 04	0.0	0.0	0.0	2.000000 05
15 16 0 0					
3.438830 05	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
15 16 2 2					
3.438830 05	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0

FIGURE 2-9. FORMATTED PRINTOUT OF INPUT DATA (SHEET 15 OF 16)

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FIGURE 2-9. FORMATTED PRINTOUT OF INPUT DATA (SHEET 16 OF 16)

- Nonzero mass orientation Euler angles (optional) (When a static deflection data set XYZ.NASOUT.DATA is read in, all masses will be rotated and a complete printout of this section of data will occur.)
- Acceleration input table data (optional)
- $[K_{ij}]$ matrices for all NB internal beams

The nonlinear beam data section prints out all the KR tables, whether these are user-input or standard tables coded into KRASH85. Similarly, the 6 x 6 linear stiffness matrix $[K_{ij}]$ is printed for all NB internal beam elements, whether $[K_{ij}]$ is directly input by the user or internally calculated in KRASH. The printed matrix corresponds to the lower right-hand quadrant of a full 12 by 12 beam stiffness matrix (figure 1-19, Vol. 1).

Certain items in this formatted printout of the input data provide additional information not directly input by the user. These include the following:

- External spring data - The actual damping constant used in the KRASH85 calculations of spring damping force is shown (CDAMP(IKM)).
- Internal beam data - Beam lengths are shown (XLB). The item called VBM is a flag denoting which, if any, of the beams the program treats as vertical beams. VBM = 1 corresponds to a vertical beam, and VBM = 0 corresponds to a normal beam. The interpretation of the beam orientation Euler angles, part of the time-history beam deflection output, depends upon whether a normal or vertical beam is noted.
- Plastic hinge and end-fixity data - The actual plastic hinge moments, calculated within the program, are output. (PLM35,...,PLM25J)
- Mass data - The coordinates for the mass and node points are not equal to those input by the user in XYZ.DATA. The input coordinates have been modified by the initial mass and node point deflections, also shown in the formatted output of the input data. All calculations in KRASH85 use the modified coordinate data.

2.3.1.3 Miscellaneous Calculated Data

The miscellaneous calculated data are illustrated in figure 2-10, and is described in the following subsections.

2.3.1.3.1 Model Parameters. - The overall vehicle weight, c.g. position, and inertias are shown. These are used to see how well the analytical model matches the actual vehicle being analyzed. This output is always for a complete airplane, even if only a half-airplane model is input (RUNMOD = 1.0). The initial position of the vehicle c.g., relative to the ground, is also shown.

2.3.1.3.2 Beam Loads and Deflections Corresponding to Yielding. - This output is generated only if NIC on card 50 (figure 2-3) is input nonzero. The beam loads and deflections corresponding to yielding are used as guidelines for establishing nonlinear deflection points for internal beam KR curves. The loads are calculated using the stress and buckling equations discussed in Volume I, Section 1.3.17, along with the appropriate yield stress for the beam material given in table 2-3 of this report.

The loads corresponding to yield stress are uncoupled loads (e.g., the shear forces are those corresponding to yielding without any bending moment applied.) Similarly, beam deflections are those resulting from the corresponding load only without the coupled load being applied. In actual loading situations, some degree of coupling is always present, so the deflections corresponding to yield provide only a rough indication of appropriate values to use for setting up KR curves. Furthermore, no attempt has been made to include in the analysis the effects of stress concentrations, geometric shape factors, and end attachment details.

2.3.1.3.3 Overall Vehicle Forces/Accelerations at Time Zero. - This block of output data is printed twice. The first time shows the six net loads (pounds and inch-pounds) at the airplane c.g., and the resulting six rigid body accelerations. These c.g. accelerations are then used to calculate the rigid body acceleration at each mass point in the model. These mass point accelerations yield inertia relief loads at each mass point. If these inertia relief loads are included in the total airplane force/moment balance, the net c.g. loads and accelerations should be zero. The second printout shows that the c.g. loads/accelerations, including inertia relief, are indeed very small (less than E-16 for all accelerations). The above calculations are performed in

subroutine NETFOR, the purpose of which is to calculate the net forces acting on each mass. These forces are used in the NASTRAN static load solution. Inertia relief loads are included to guarantee that a balanced set of applied loads is input to the NASTRAN model.

2.3.1.3.4 Individual Mass Forces Accelerations At Time Zero. - Figure 2-10 also shows this list of loads and accelerations for each mass in the model. The specific data output for each mass is as follows:

Line 1: Gravity loads, c.g. axes

Line 2: External loads, c.g. axes. These are the loads due to input time histories of external loads at specified masses, per the 1500-series cards. This is the method used to input aerodynamic loads into the model for the sample case.

Line 3: Aerodynamic lift, c.g. axes. These data reflects any aerodynamic lift calculated by means of inputting 10 on the 3100-series cards. This option is not used in the sample case. The aerodynamic loads calculated using the 3300-series aero data are not included in the load calculations in NETFOR. Therefore, these loads will not get into the NASTRAN model to determine the proper balanced initial conditions.

Line 4: Inertia loads, c.g. axes. The inertia loads are calculated in NETFOR, as described in Section 2.3.1.4 above, to achieve a balanced set of loads for input to NASTRAN.

Line 5: Net loads, c.g. axes. These loads are the sum of all the above loads. The net loads are the input to the NASTRAN static load solution.

Line 6: Accelerations, mass axes. These are the rigid body airplane accelerations at time zero at each mass point. As explained in Section 2.3.1.4, these accelerations are calculated from the airplane c.g. acceleration, which in turn is calculated from all the loads except inertia relief loads. The mass point accelerations in line 6 times the mass point inertia matrix yields the inertia relief loads. These accelerations are output in mass axes to facilitate comparisons with KRASH85 time-history output at time zero. The accelerations for the latter are also in mass axes. The two sets of accelerations should be equal for a properly balanced set of initial conditions.

All quantities shown in this output have the units of pounds or inch-pounds for loads, and g's or rad/sec^2 for accelerations. The sign convention

is positive forward, right, and down, with right-hand moments about these axes. These data are presented basically as reference information; the user need not examine these data closely. The determination of whether or not the balanced initial conditions are acceptably accurate can be made based on data that are presented at the time zero printout from program KRASH85. (Section 2.3.3).

2.3.2 MSC/TRAN Output

The output data from MSC/NASTRAN are discussed in this section. Familiarity with these output data is not necessary to successfully run program KRASH. If difficulties occur in achieving a balanced initial condition, then a review of this data may be necessary to help isolate the problem.

2.3.2.1 Executive Control Deck Echo

This is shown in figure 2-11, and consists of only four lines. These are generated automatically by program KRASHIC. SOL 24 refers to Rigid Format Solution No. 24, which is the small deflection linear static solution.

2.3.2.2 Case Control Deck Echo

This is also shown in figure 2-11, and contains only 13 cards. These are generated automatically by program KRASHIC. The output control card DISPLACEMENT (PRINT,PUNCH) = ALL, used in conjunction with the appropriate JCL cards, causes the output displacement vector to be written as data set XYZ.NASOUT.DATA in the user's library. If the user wants to eliminate or revise some of the NASTRAN output data, then Format No. 1020 in subroutine NAST, in program KRASHIC, should be revised accordingly.

2.3.2.3 Input Bulk Data Deck Echo

The complete input bulk data deck is reproduced in this echo, shown as figure 2-12. All these cards are generated automatically by program KRASHIC, in subroutines NAST and NAST10. The CONM2 (mass property), PLOTEL (plot data) and EIGR (eigenvalue) cards are not used in the static load solution employed (SOL 24). KRASHIC converts a KRASH85 input data set into a NASTRAN

MODEL PARAMETERS

VEHICLE WT = 1.8655600 05

VEHICLE CG POSITION

X (FS) = 8.421390 02
Y (BL) = 0.0
Z (ML) = 2.094230 02

VEHICLE INERTIAS (IN-LB-SEC**2)

I (XX) = 3.392920 07
I (YY) = 3.879550 07
I (ZZ) = 7.125540 07
I (XY) = 0.0
I (XZ) = 0.0
I (YZ) = 1.950610 06

VEHICLE CG INITIAL GROUND COORDINATES

XCG IS THE DISTANCE FROM SLOPE/GROUND INTERSECTION TO VEHICLE CG, +FORWARD
ZCG IS THE DISTANCE FROM GROUND PLANE TO VEHICLE CG, +DOWN

XCG = 0.0

ZCG = -1.384990 02

BEAM LOADS

BEAM		I	J	H	N	BUCKLING	AXIAL LOAD		COMPRESSION	SHEAR FORCE		ROLL(X)	MOMENT PITCH(Y)	YAW(Z)		BEAM				
I	J						TENSION			LATERAL(Y)	VERTICAL(Z)			I	J	H	N			
1	2	0	7.15840 08	1.12000 06	1.08800 06	3.64480 05	3.64480 05	0.0	2.19580 07	1.31040 07	1	2	0	0	2.19580 07	1.31040 07	1	2	0	0
2	3	0	3.30270 08	1.26000 06	1.22400 06	4.10040 05	4.10040 05	0.0	2.64440 07	1.47680 07	2	3	0	0	2.64440 07	1.47680 07	2	3	0	0
3	4	0	3.31460 08	1.26000 06	1.22400 06	4.10040 05	4.10040 05	0.0	5.22140 07	2.61070 07	3	4	0	0	5.22140 07	2.61070 07	3	4	0	0
4	5	0	2.29280 08	2.06500 06	2.00600 06	6.72010 05	6.72010 05	0.0	8.25710 07	2.82320 07	4	5	0	0	8.25710 07	2.82320 07	4	5	0	0
5	6	0	4.64850 08	2.06500 06	2.00600 06	6.72010 05	6.72010 05	0.0	5.97580 07	2.39550 07	5	6	0	0	5.97580 07	2.39550 07	5	6	0	0
6	7	0	1.75280 09	1.99500 06	1.93800 06	6.49230 05	6.49230 05	0.0	5.25450 07	2.20230 07	6	7	0	0	5.25450 07	2.20230 07	6	7	0	0
7	8	0	4.72710 08	1.68000 06	1.63200 06	5.46720 05	5.46720 05	0.0	4.25930 07	2.31650 07	7	8	0	0	4.25930 07	2.31650 07	7	8	0	0
8	9	0	2.46950 08	1.29500 06	1.25800 06	4.21430 05	4.21430 05	0.0	3.73330 07	2.23320 07	8	9	0	0	3.73330 07	2.23320 07	8	9	0	0
9	10	0	8.16590 07	8.75000 05	8.50000 05	2.84750 05	2.84750 05	0.0	6.12000 07	6.46000 06	9	10	0	0	6.12000 07	6.46000 06	9	10	0	0
10	11	1	3.84660 08	1.89000 06	1.83600 06	6.15060 05	6.15060 05	0.0	5.40600 08	3.87600 09	10	11	1	0	5.40600 08	3.87600 09	10	11	1	0
11	12	1	1.50030 08	2.21200 06	2.14880 06	7.19850 05	7.19850 05	0.0	3.87600 08	3.46800 09	11	12	1	0	3.87600 08	3.46800 09	11	12	1	0
12	13	0	5.48330 07	1.97050 06	1.91420 06	6.41260 05	6.41260 05	0.0	1.59800 08	1.97200 09	12	13	0	0	1.59800 08	1.97200 09	12	13	0	0
13	14	0	2.29830 07	1.42450 06	1.38380 06	4.63570 05	4.63570 05	0.0	6.80000 07	7.14000 08	13	14	0	0	6.80000 07	7.14000 08	13	14	0	0
14	15	0	1.33650 07	7.00000 05	6.80000 05	2.27800 05	2.27800 05	0.0	4.08000 07	7.20000 08	14	15	0	1	4.08000 07	7.20000 08	14	15	0	1
15	16	1	7.15830 06	3.76000 05	3.12000 05	1.17920 05	1.17920 05	0.0	2.85480 07	3.90000 06	15	16	1	1	2.85480 07	3.90000 06	15	16	1	1
16	17	1	7.15860 06	3.76000 05	3.12000 05	1.17920 05	1.17920 05	0.0	2.85480 07	3.90000 06	16	17	1	1	2.85480 07	3.90000 06	16	17	1	1
17	18	2	3.56450 07	7.50000 02	7.50000 02	2.51250 02	2.51250 02	0.0	1.79250 07	1.79250 07	17	18	2	0	1.79250 07	1.79250 07	17	18	2	0
18	19	3	3.56450 07	7.50000 02	7.50000 02	2.51250 02	2.51250 02	0.0	1.79250 07	1.79250 07	18	19	3	0	1.79250 07	1.79250 07	18	19	3	0
19	2	19	0.983280 06	7.50000 02	7.50000 02	2.51250 02	2.51250 02	0.0	2.43750 06	2.43750 06	19	2	19	1	2.43750 06	2.43750 06	19	2	19	1
20	6	12	0	4.61490 06	1.42450 06	1.38380 06	4.63570 05	0.0	6.80000 07	7.14000 08	20	6	12	0	6.80000 07	7.14000 08	20	6	12	0
21	9	14	0	1.79710 06	1.42450 06	1.38380 06	4.63570 05	0.0	6.80000 07	7.14000 08	21	9	14	0	6.80000 07	7.14000 08	21	9	14	0
22	12	0	2.67280 06	1.42450 06	1.38380 06	4.63570 05	4.63570 05	0.0	6.80000 07	7.14000 08	22	12	0	0	6.80000 07	7.14000 08	22	12	0	0
23	2	20	0	9.96420 04	3.25730 03	3.25730 03	2.31880 03	0.0	1.60000 04	1.60000 04	23	2	20	0	1.60000 04	1.60000 04	23	2	20	0
24	2	21	0	9.86970 04	2.09460 03	2.09460 03	1.49110 03	0.0	1.60000 04	1.60000 04	24	2	21	0	1.60000 04	1.60000 04	24	2	21	0
25	15	16	0	0	7.00000 05	6.80000 05	2.27800 05	0.0	0.0	0.0	25	15	16	0	0.0	0.0	25	15	16	0
26	15	16	2	0	7.00000 05	6.80000 05	2.27800 05	0.0	0.0	0.0	26	15	16	2	0.0	0.0	26	15	16	2
27	15	0	2.16180 05	7.00000 05	6.80000 05	2.27800 05	2.27800 05	0.0	4.08000 07	2.72000 08	27	15	0	0	4.08000 07	2.72000 08	27	15	0	0
28	15	0	2.16180 05	7.00000 05	6.80000 05	2.27800 05	2.27800 05	0.0	4.08000 07	2.72000 08	28	15	0	2	4.08000 07	2.72000 08	28	15	0	2

FIGURE 2-10. MISCELLANEOUS CALCULATED DATA (SHEET 1 OF 5)

BEAM DEFLECTIONS

BEAM				DEFLECTION		COMPRESSION	FIYI	TRANSLATION DUE TO		BMHYI	ROTATION ABOUT			
IJ	I	J	M	N	BUCKLING			TENSION	FIZI		BHIZI	X-AXIS	Y-AXIS	Z-AXIS
1	1	2	0	0	2.2600 02	3.5350-01	3.4340-01	8.4600-02	5.0490-02	1.2040-01	1.2040-01	0.0	3.5770-03	3.5770-03
2	2	3	0	0	1.4710 02	5.6110-01	5.4510-01	3.2740-01	1.8280-01	2.9420-01	2.9420-01	0.0	5.5060-03	5.5060-03
3	3	4	0	0	1.4720 02	5.6010-01	5.4410-01	3.2560-01	1.8280-01	5.1820-01	5.1820-01	0.0	9.7160-03	9.7160-03
4	4	5	0	0	7.7750 01	7.0030-01	6.8030-01	9.6470-01	3.2980-01	8.1020-01	8.1020-01	0.0	1.2150-02	1.2150-02
5	5	6	0	0	1.1070 01	9.9180-01	4.7780-01	3.3420-01	1.3390-01	3.3910-01	3.3910-01	0.0	7.2390-03	7.2390-03
6	6	7	0	0	2.4640 02	2.8040-01	2.7240-01	4.8810-02	2.0460-02	8.2670-02	8.2670-02	0.0	3.0960-03	3.0960-03
7	7	8	0	0	1.5850 02	5.6320-01	5.4710-01	3.0610-01	1.8650-01	3.2240-01	3.2240-01	0.0	6.0120-03	6.0120-03
8	8	9	0	0	1.0920 02	5.7270-01	5.5640-01	4.5940-01	2.7480-01	5.9510-01	5.9510-01	0.0	1.0910-02	1.0910-02
9	9	10	0	0	7.0000 01	7.5010-01	7.2860-01	2.4590 00	2.4950-01	1.0410 00	1.0410 00	0.0	1.4570-02	1.4570-02
10	5	11	0	1	9.1000 01	4.7110-01	4.3430-01	9.3720-02	6.7200-01	1.8490 01	1.8490 01	0.0	4.3430-01	4.3430-01
11	11	12	1	0	4.1120 01	6.0620-01	5.8640-01	3.0560-01	2.7340 00	3.4000 01	3.4000 01	0.0	5.8390-01	5.8390-01
12	12	13	0	0	1.7420 01	6.4380-01	6.2540-01	5.7350-01	7.0770 00	3.8350 01	3.8350 01	0.0	6.2540-01	6.2540-01
13	13	14	0	0	1.0470 01	6.4870-01	6.3020-01	1.1710 00	1.2300 01	3.6920 01	3.6920 01	0.0	6.3020-01	6.3020-01
14	14	15	0	1	1.2580 01	9.5900-01	6.4010-01	1.5940 00	1.0560 01	4.0170 01	4.0170 01	0.0	6.4010-01	6.4010-01
15	12	16	1	1	6.4850 00	3.4060-01	2.8260-01	4.1240 00	5.6340-01	7.1700 00	7.1700 00	0.0	2.8260-01	2.8260-01
16	14	17	1	1	6.4850 00	3.4060-01	2.8260-01	4.1240 00	5.6340-01	7.1700 00	7.1700 00	0.0	2.8260-01	2.8260-01
17	11	18	2	0	1.0590 04	2.2280-01	2.2280-01	2.0640-03	2.0660-03	6.6180 00	6.6180 00	0.0	2.2280-01	2.2280-01
18	11	18	3	0	1.0590 04	2.2280-01	2.2280-01	2.0640-03	2.0660-03	6.6180 00	6.6180 00	0.0	2.2280-01	2.2280-01
19	2	19	1	0	2.0510 03	1.5640-01	2.2280-01	2.0660-03	2.0660-03	6.6180 00	6.6180 00	0.0	2.2280-01	2.2280-01
20	6	12	0	0	3.3160 00	1.0240 00	1.5640-01	5.2600-03	5.2600-03	3.2620 00	3.2620 00	0.0	1.5640-01	1.5640-01
21	9	14	0	0	2.9270 00	2.3200 00	2.9540-01	4.6030 00	4.8330 01	9.6950 01	9.6950 01	0.0	9.9440-01	9.9440-01
22	12	0	0	0	3.5690 00	1.9020 00	2.2540 00	5.3570 01	5.6250 02	4.9790 02	4.9790 02	0.0	2.2540 00	2.2540 00
23	2	20	0	0	9.7420 00	3.1850-01	1.8480 00	2.9540 00	3.1010 02	3.3480 02	3.3480 02	0.0	1.8480 00	1.8480 00
24	2	21	0	0	1.5080 01	3.2000-01	1.8500-01	1.5240 00	1.5240 00	2.1130 00	2.1130 00	0.0	3.1850-01	3.1850-01
25	15	16	0	0	0.0	2.0360 00	3.2000-01	9.9400-01	9.9400-01	2.1330 00	2.1330 00	0.0	3.2000-01	3.2000-01
26	15	16	2	2	0.0	2.0360 00	1.9770 00	0.0	0.0	0.0	0.0	0.0	0.0	0.0
27	15	0	0	0	1.6000 00	5.1810 00	5.0330 00	7.6980 02	5.1320 03	2.4840 03	2.4840 03	0.0	5.0330 00	5.0330 00
28	15	0	2	0	1.6000 00	5.1810 00	5.0330 00	7.6980 02	5.1320 03	2.4840 03	2.4840 03	0.0	5.0330 00	5.0330 00

OVERALL VEHICLE FORCES AND ACCELS(G-S), A/P AXES

FX= -1.915710 03 AX= -1.026880-02
 FY= 0.0 AY= 0.0
 FZ= 4.091090 03 AZ= 2.192960-02
 MX= 0.0 PDY= 0.0
 MY= -1.452480 05 QDT= -3.743940-03
 MZ= 0.0 RDT= 0.0

OVERALL VEHICLE FORCES AND ACCELS(G-S), INCLUDING INERTIA RELIEF, A/P AXES

FX= -1.725290-13 AX= -9.248090-19
 FY= 0.0 AY= 0.0
 FZ= 5.115910-12 AZ= 2.742290-17
 MX= 0.0 PDY= 0.0
 MY= 8.294590-10 QDT= 2.138030-17
 MZ= 0.0 RDT= 0.0

INDIVIDUAL MASS FORCES/MOMENTS AND ACCELS
 GRAVITY/EXTERNAL/LIFT/INERTIA/NET/ACCELS(G-S)

FIGURE 2-10. MISCELLANEOUS CALCULATED DATA (SHEET 2 OF 5)

ACCELS IN MASS AXES, ALL OTHERS IN A/P AXES

MASS	X	Y	Z	L	M	N
1	-2.765680 01 2.128250-01 0.0 4.257970 01 1.513570 01 -2.680040-02 0.0	0.0 0.0 0.0 0.0 0.0 0.0	1.584760 03 -9.499980 01 0.0 -4.505500 01 1.444700 03 2.848600-02 0.0	0.0 0.0 0.0 0.0 0.0 0.0	0.0 0.0 0.0 1.497580 02 1.497580 02 -3.743940-03 0.0	0.0 0.0 0.0 0.0 0.0 0.0
2	-1.581670 02 1.391640 00 0.0 2.198860 02 6.311050 01 -2.419680-02 0.0	0.0 0.0 0.0 0.0 0.0 0.0	9.063120 03 -6.244980 02 0.0 -2.485340 02 8.190090 03 2.747240-02 0.0	0.0 0.0 0.0 0.0 0.0 0.0	0.0 0.0 0.0 1.123180 03 1.123180 03 -3.743940-03 0.0	0.0 0.0 0.0 0.0 0.0 0.0
3	-2.672870 02 3.753000 00 0.0 3.095180 02 4.598340 01 -2.015430-02 0.0	0.0 0.0 0.0 0.0 0.0 0.0	1.531580 04 -1.861000 03 0.0 -3.923910 02 1.506240 04 2.565690-02 0.0	0.0 0.0 0.0 0.0 0.0 0.0	0.0 0.0 0.0 3.629190 02 3.629190 02 -3.743940-03 0.0	0.0 0.0 0.0 0.0 0.0 0.0
4	-2.285140 02 6.177640 00 0.0 2.106410 02 -1.169550 01 -1.605290-02 0.0	0.0 0.0 0.0 0.0 0.0 0.0	1.309400 04 -4.715000 03 0.0 -3.143230 02 8.064690 03 2.402250-02 0.0	0.0 0.0 0.0 0.0 0.0 0.0	0.0 0.0 0.0 2.497770 02 2.497770 02 -3.743940-03 0.0	0.0 0.0 0.0 0.0 0.0 0.0
5	-3.795640 02 0.0 0.0 2.383590 02 -1.412050 02 -1.095770-02 0.0	0.0 0.0 0.0 0.0 0.0 0.0	2.174930 04 -7.901000 03 0.0 -4.767100 02 1.337160 04 2.191510-02 0.0	0.0 0.0 0.0 0.0 0.0 0.0	0.0 0.0 0.0 4.705010 02 4.705010 02 -3.743940-03 0.0	0.0 0.0 0.0 0.0 0.0 0.0
6	-1.378740 02 -3.794300 00 0.0 5.699980 01 -8.466870 01 -7.253550-03 0.0	0.0 0.0 0.0 0.0 0.0 0.0	7.900300 03 -1.991000 03 0.0 -1.649010 02 5.744400 03 2.085580-02 0.0	0.0 0.0 0.0 0.0 0.0 0.0	0.0 0.0 0.0 4.492730 02 4.492730 02 -3.743940-03 0.0	0.0 0.0 0.0 0.0 0.0 0.0
7	-1.603700 02 -6.128490 00 0.0 4.767340 01 -1.188250 02 -5.259970-03 0.0	0.0 0.0 0.0 0.0 0.0 0.0	9.189300 03 -2.315990 03 0.0 -1.835610 02 6.689750 03 1.995870-02 0.0	0.0 0.0 0.0 0.0 0.0 0.0	0.0 0.0 0.0 5.241520 02 5.241520 02 -3.743940-03 0.0	0.0 0.0 0.0 0.0 0.0 0.0
8	-1.734160 02 -3.083090 00 0.0 8.740430 00 -1.677590 02 -9.534570-04 0.0	0.0 0.0 0.0 0.0 0.0 0.0	9.936890 03 -7.853940 02 0.0 -1.873590 02 8.964130 03 1.884840-02 0.0	0.0 0.0 0.0 0.0 0.0 0.0	0.0 0.0 0.0 6.739100 02 6.739100 02 -3.743940-03 0.0	0.0 0.0 0.0 0.0 0.0 0.0

FIGURE 2-10. MISCELLANEOUS CALCULATED DATA (SHEET 3 OF 5)

9	-9.049400 01	0.0	5.701130 03	0.0	0.0	0.0	0.0
	-2.606030 00	0.0	-4.499920 02	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	-2.051340 01	0.0	-1.036820 02	0.0	1.564520 02	0.0	0.0
10	-1.226140 02	0.0	5.147460 03	0.0	1.564520 02	0.0	0.0
	3.492270-03	0.0	1.820390-02	0.0	-3.743940-03	0.0	0.0
	-1.077520 02	0.0	6.174260 03	0.0	0.0	0.0	0.0
	1.113100 02	0.0	1.744520 04	0.0	0.0	0.0	0.0
11	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	-5.832300 01	0.0	-1.062460 02	0.0	4.042710 02	0.0	0.0
	-5.476490 01	0.0	2.351330 04	0.0	4.042710 02	0.0	0.0
	9.334750-03	0.0	1.726520-02	0.0	-3.743940-03	0.0	0.0
12	-1.687430 02	0.0	9.669130 03	0.0	0.0	0.0	0.0
	3.388580 01	1.032150 02	-1.541880 04	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	1.117320 02	0.0	-2.108210 02	1.457610 01	5.188730 02	-6.208550 00	0.0
13	-2.312540 01	1.032150 02	-5.960510 03	1.457610 01	5.188730 02	-6.208550 00	0.0
	-1.150580-02	1.525480-04	2.182500-02	-2.098680-06	-3.743860-03	2.506170-05	0.0
	-1.756360 02	0.0	1.006410 04	0.0	0.0	0.0	0.0
	1.876990 02	3.683100 02	-2.818520 04	0.0	0.0	0.0	0.0
14	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	1.014180 02	0.0	-2.188230 02	2.287700 01	4.592330 02	-9.485500 00	0.0
	1.134810 02	3.683100 02	-1.833990 04	2.287700 01	4.592330 02	-9.485500 00	0.0
	-9.930490-03	2.941850-04	2.180440-02	-3.491460-06	-3.743620-03	4.891870-05	0.0
15	-9.224470 01	0.0	5.285700 03	0.0	0.0	0.0	0.0
	2.199500 02	4.798290 02	-2.138760 04	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	3.976970 01	0.0	-1.230950 02	1.263750 01	1.971100 02	-5.449880 00	0.0
16	1.674750 02	4.798290 02	-1.621500 04	1.263750 01	1.971100 02	-5.449880 00	0.0
	-7.301670-03	4.938000-04	2.146410-02	-6.295250-06	-3.743000-03	8.396950-05	0.0
	-6.559120 01	0.0	3.758430 03	0.0	0.0	0.0	0.0
	1.292920 02	4.572830 02	-1.781250 04	0.0	0.0	0.0	0.0
17	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	1.736000 01	0.0	-7.946890 01	8.375350 00	9.676180 01	-4.356140 00	0.0
	8.106090 01	4.572830 02	-1.413350 04	8.375350 00	9.676180 01	-4.356140 00	0.0
	-4.461750-03	5.670310-04	2.116700-02	-1.982760-05	-3.742660-03	9.608070-05	0.0
18	-2.691180 01	0.0	1.542070 03	0.0	0.0	0.0	0.0
	5.605590 01	1.069880 02	-6.239730 03	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	4.269080 00	0.0	-3.223660 01	1.413310 00	3.375600 01	-9.256610-01	0.0
19	3.341320 01	1.069880 02	-4.729900 03	1.413310 00	3.375600 01	-9.256610-01	0.0
	-2.578320-03	3.714340-04	2.092260-02	-1.843880-05	-3.743350-03	6.418250-05	0.0
	-9.422520 01	0.0	5.399180 03	0.0	0.0	0.0	0.0
	-5.602650 00	-2.057530 01	-2.699590 02	0.0	0.0	0.0	0.0
20	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	7.499040 01	0.0	-1.190860 02	2.410580 02	9.622590 01	9.971360 03	0.0
	-2.483740 01	-2.057530 01	5.010130 03	2.410580 02	9.622590 01	9.971360 03	0.0
	-1.441050-02	-8.695270-04	2.169710-02	-2.035810-04	-3.727580-03	-2.844630-04	0.0
21	-8.988040 01	0.0	5.150220 03	0.0	0.0	0.0	0.0
	-5.131290 00	-1.645120 01	-2.577240 02	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	4.564990 01	0.0	-1.083470 02	2.292630 02	9.183470 01	9.968400 03	0.0

FIGURE 2-10. MISCELLANEOUS CALCULATED DATA (SHEET 4 OF 5)

18	-4.93618D 01	-1.64512D 01	4.78414D 03	2.29263D 02	9.18382D 01	9.96840D 03
	-9.36166D-03	-7.76186D-04	2.08112D-02	-2.21321D-04	-3.72978D-03	-2.38453D-04
	-3.35372D 01	0.0	1.92171D 03	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0
	1.97452D 01	0.0	-3.54470D 01	2.42191D-02	5.99037D 00	-1.68548D-02
	-1.37920D 01	0.0	1.88626D 03	2.42191D-02	5.99037D 00	-1.68548D-02
	-1.02326D-02	1.29277D-04	1.84649D-02	-2.09858D-06	-3.74386D-03	2.50486D-05
19	-4.15289D 00	0.0	2.37964D 02	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0
	6.20994D 00	0.0	-5.74830D 00	0.0	1.12318D 00	0.0
	2.05705D 00	0.0	2.32215D 02	0.0	1.12318D 00	0.0
	-2.60384D-02	0.0	2.42105D-02	0.0	-3.74394D-03	0.0
20	-1.74491D 01	0.0	9.99848D 02	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0
	2.40667D 01	0.0	-2.79347D 01	0.0	3.74394D 00	0.0
	6.61759D 00	0.0	9.71913D 02	0.0	3.74394D 00	0.0
	-2.39509D-02	0.0	2.80341D-02	0.0	-3.74394D-03	0.0
21	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0

FIGURE 2-10. MISCELLANEOUS CALCULATED DATA (SHEET 5 OF 5)

NASTRAN EXECUTIVE CONTROL DECK ECHO

ID MAGAMON,D7612
SOL 24
DIAG 8
CEND

*** USER WARNING MESSAGE 4519, A TIME CARD IS MISSING. DEFAULT TIME LIMIT IS ONE MINUTE.

INITIAL CONDITION STATIC SOLUTION

CASE CONTROL DECK ECHO

CARD COUNT	
1	TITLE=LT.SAMPLE.DATA
2	SUBTITLE=21 MASS/28 BEAM TEST CASE ONLY-NOT VALID AIRPLANE MODEL
3	LABEL=INITIAL CONDITION STATIC SOLUTION
4	LOAD=10
5	ECHO=BOTH
6	OUTPUT
7	DISPLACEMENT(PRINT,PUNCH)=ALL
8	SPCFORCES=ALL
9	ELFORCE=ALL
10	GPFORCE=ALL
11	ESE=ALL
12	OLoad=ALL
13	BEGIN BULK

FIGURE 2-11. MSC/NASTRAN EXECUTIVE AND CASE CONTROL DECKS (SHEET 2 OF 2)

INPUT BULK DATA DECK ECHO										
1	2	3	4	5	6	7	8	9	10	
KRASH MASS POINTS CONVERTED TO NASTRAN GRID CARDS										
GRID*	100				198.9691085700	0.0		*	100G	
* 100G	219.0072894000				246					
GRID*	200				299.9715105900	0.0		*	200G	
* 200G	217.9331623000				246					
GRID*	300				459.9920437930	0.0		*	300G	
* 300G	208.2776436000				246					
GRID*	400				619.9961184340	0.0		*	400G	
* 400G	205.8532906000				246					
GRID*	500				820.0000000000	0.0		*	500G	
* 500G	200.2000000000				123456					
GRID*	600				960.0003900044	0.0		*	600G	
* 600G	212.2604349000				246					
GRID*	700				1039.9825895500	0.0		*	700G	
* 700G	207.5775777000				246					
GRID*	800				1200.0196003700	0.0		*	800G	
* 800G	224.2425320000				246					
GRID*	900				1360.0623369000	0.0		*	900G	
* 900G	258.3539810000				246					
GRID*	1000				1570.4121330000	0.0		*	1000G	
* 1000G	299.3524450000				246					
GRID*	1100				801.2762329200	-118.3620482900*		1100G		
* 1100G	188.7549811000				0					
GRID*	1200				852.0816817000	-271.7586170000*		1200G		
* 1200G	205.4417780000				0					
GRID*	1300				942.8991904000	-430.3945420000*		1300G		
* 1300G	226.0702350000				0					
GRID*	1400				1044.4314080000	-582.8600137000*		1400G		
* 1400G	254.3458500000				0					
GRID*	1500				1110.1047930000	-740.1657271000*		1500G		
* 1500G	269.6958900000				0					
GRID*	1600				719.0791973500	-321.8893812000*		1600G		
* 1600G	167.7378190000				0					
GRID*	1700				902.1047448000	-551.6346446100*		1700G		
* 1700G	196.9346760000				0					
GRID*	1800				887.1832870000	-132.3628592000*		1800G		
* 1800G	91.3225001000				0					
GRID*	1900				279.2696309000	0.0		*	1900G	
* 1900G	84.1201432000				246					
GRID*	2000				299.9019012500	0.0		*	2000G	
* 2000G	237.8378928000				246					
GRID*	2100				299.9269427700	0.0		*	2100G	
* 2100G	237.9330628000				0					
KRASH MASSLESS NODE POINTS CONVERTED TO NASTRAN GRIDS										
GRID*	501				775.1000000000	-48.0000000000*		501G		
* 501G	181.0000000000				0					

FIGURE 2-12. MSC/NASTRAN INPUT BULK DATA DECK ECHO (SHEET 1 OF 11)

LT. SAMPLE DATA
21 MASS/28 BEAM TEST CASE ONLY-NOT VALID AIRPLANE MODEL

INITIAL CONDITION STATIC SOLUTION

INPUT BULK DATA DECK ECHO										
1	2	3	4	5	6	7	8	9	10	
GRID*	1101									
* 1101G	186.6946611000				773.8807694600		-118.3604807600*		1101G	
GRID*	1102									
* 1102G	180.4333756000				886.9870388800		-131.7657883000*		1102G	
GRID*	1103									
* 1103G	180.4333756000				886.9870388800		-131.7657883000*		1103G	
GRID*	1201									
* 1201G	202.3218480000				811.5560511000		-321.5615706000*		1201G	
GRID*	1401									
* 1401G	230.1605510000				993.4773320000		-551.3099517000*		1401G	
GRID*	1501									
* 1501G	276.2174300000				1145.4453490000		-740.2282724000*		1501G	
GRID*	1502									
* 1502G	269.6958900000				1110.1047930000		-740.1657271000*		1502G	
GRID*	1601									
* 1601G	201.6861040000				735.4614452000		-321.4752190000*		1601G	
GRID*	1602									
* 1602G	167.7378190000				719.0791973500		-321.8893812000*		1602G	
GRID*	1701									
* 1701G	229.4678850000				917.3858480000		-550.9002126000*		1701G	
GRID*	201									
* 201G	146.6867195000				279.1302763000		0.0	*	201G	
\$										
\$										
KRASH MASS POINT/NODE POINTS CONVERTED TO RBAR ELEMENTS										
RBAR	501	500	501	123456					123456	
PLOTTEL	501	500	501							
RBAR	1101	1100	1101	123456					123456	
PLOTTEL	1101	1100	1101							
RBAR	1102	1100	1102	123456					123456	
PLOTTEL	1102	1100	1102							
RBAR	1103	1100	1103	123456					123456	
PLOTTEL	1103	1100	1103							
RBAR	1201	1200	1201	123456					123456	
PLOTTEL	1201	1200	1201							
RBAR	1401	1400	1401	123456					123456	
PLOTTEL	1401	1400	1401							
RBAR	1501	1500	1501	123456					123456	
PLOTTEL	1501	1500	1501							
RBAR	1502	1500	1502	123456					123456	
PLOTTEL	1502	1500	1502							
RBAR	1601	1600	1601	123456					123456	
PLOTTEL	1601	1600	1601							
RBAR	1602	1600	1602	123456					123456	
PLOTTEL	1602	1600	1602							
RBAR	1701	1700	1701	123456					123456	
PLOTTEL	1701	1700	1701							
RBAR	201	200	201	123456					123456	
PLOTTEL	201	200	201							
\$										

FIGURE 2-12. MSC/NASTRAN INPUT BULK DATA DECK ECHO (SHEET 2 OF 11)

INPUT BULK DATA DECK ECHO										
1	2	3	4	5	6	7	8	9	10	
\$ KRAISH MASS POINTS CONVERTED TO NASTRAN CONM2 CARDS										
CONM2	100	100	0.	20000.	2.053	0.	7500.			WT 100
+MT 100	5757.	0.	20000.	0.	0.	0.	7500.			WT 200
CONM2	200	200	0.	150000.	11.742	0.	49500.			WT 300
+MT 200	44540.	0.	150000.	0.	0.	0.	49500.			WT 400
CONM2	300	300	0.	48468.	19.842	0.	51545.			WT 500
+MT 300	81390.	0.	48468.	0.	0.	0.	51545.			WT 600
CONM2	400	400	0.	33358.	16.964	0.	39695.			WT 700
+MT 400	98135.	0.	33358.	0.	0.	0.	39695.			WT 800
CONM2	500	500	0.	62835.	28.177	0.	73255.			WT 900
+MT 500	245530.	0.	62835.	0.	0.	0.	73255.			WT 1000
CONM2	600	600	0.	60000.	10.235	0.	100000.			WT 1100
+MT 600	40692.	0.	60000.	0.	0.	0.	100000.			WT 1200
CONM2	700	700	0.	70000.	11.905	0.	100000.			WT 1300
+MT 700	43768.	0.	70000.	0.	0.	0.	100000.			WT 1400
CONM2	800	800	0.	90000.	12.874	0.	150000.			WT 1500
+MT 800	44049.	0.	90000.	0.	0.	0.	150000.			WT 1600
CONM2	900	900	0.	20894.	7.386	0.	13020.			WT 1700
+MT 900	48125.	0.	20894.	0.	0.	0.	13020.			WT 1800
CONM2	1000	1000	0.	53990.	7.999	0.	79315.			WT 1900
+MT 1000	107650.	0.	53990.	0.	0.	0.	79315.			WT 2000
CONM2	1100	1100	0.	138580.	25.053	0.	360000.			WT 2100
+MT 1100	15213.	0.	138580.	0.	0.	0.	360000.			
CONM2	1200	1200	0.	122630.	26.077	0.	300000.			
+MT 1200	19510.	0.	122630.	0.	0.	0.	300000.			
CONM2	1300	1300	0.	52619.	13.696	0.	110000.			
+MT 1300	7272.	0.	52619.	0.	0.	0.	110000.			
CONM2	1400	1400	0.	25823.	9.738	0.	60000.			
+MT 1400	4408.	0.	25823.	0.	0.	0.	60000.			
CONM2	1500	1500	0.	9014.	3.996	0.	18000.			
+MT 1500	1671.	0.	9014.	0.	0.	0.	18000.			
CONM2	1600	1600	0.	25746.	13.990	0.	29375.			
+MT 1600	3652.	0.	25746.	0.	0.	0.	29375.			
CONM2	1700	1700	0.	24588.	13.345	0.	28178.			
+MT 1700	3712.	0.	24588.	0.	0.	0.	28178.			
CONM2	1800	1800	0.	1600.	4.979	0.	2000.			
+MT 1800	371.	0.	1600.	0.	0.	0.	2000.			
CONM2	1900	1900	0.	150.	0.308	0.	250.			
+MT 1900	12.	0.	150.	0.	0.	0.	250.			
CONM2	2000	2000	0.	500.	1.295	0.	500.			
+MT 2000	500.	0.	500.	0.	0.	0.	500.			
CONM2	2100	2100	0.	500.	1.295	0.	500.			
+MT 2100	500.	0.	500.	0.	0.	0.	500.			
\$ KRAISH SYMMETRIC MODEL BOUNDARY POINTS CONVERTED TO NASTRAN GROUNDED GRIDS										
GRID#	1199				852.0816817000	0.0	*	1199G		
* 1199G	205.4417780000				1110.1047930000	0.0	*	1499G		
GRID#	1499									

FIGURE 2-12. MSC/NASTRAN INPUT BULK DATA DECK ECHO (SHEET 3 OF 11)

LT-SAMPLE DATA
21 MASS/28 BEAM TEST CASE ONLY-NOT VALID AIRPLANE MODEL
INITIAL CONDITION STATIC SOLUTION

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INPUT BULK DATA DECK ECHO										
	1	2	3	4	5	6	7	8	9	10
* 1498G	269.6958900000									
GRID*	1498					1110.1047930000	0.0			* 1498G
* 1498G	269.6958900000									
\$										
KRAISH BEAM ELEMENTS CONVERTED TO NASTRAN CBAR, PBAR, AND MAT1 CARDS										
\$										
CBAR*	1000									
* 1000S	0.0									* 1000S
* 1000T										* 1000T
* 1000U										* 1000U
PBAR*										
* 1000A	31000.00000000									* 1000A
MAT1*	1000									* 1000B
* 1000B										* 1000C
* 1000C	35000.000									
\$										
CBAR*	2000									
* 2000S	0.0									* 2000S
* 2000T										* 2000T
* 2000U										* 2000U
PBAR*										
* 2000A	38500.00000000									* 2000A
MAT1*	2000									* 2000B
* 2000B										* 2000C
* 2000C	35000.000									
\$										
CBAR*	3000									
* 3000S	0.0									* 3000S
* 3000T										* 3000T
* 3000U										* 3000U
PBAR*										
* 3000A	43000.00000000									* 3000A
MAT1*	3000									* 3000B
* 3000B										* 3000C
* 3000C	35000.000									
\$										
CBAR*	4000									
* 4000S	0.0									* 4000S
* 4000T										* 4000T
* 4000U										* 4000U
PBAR*										
* 4000A	68000.00000000									* 4000A
MAT1*	4000									* 4000B
* 4000B										* 4000C
* 4000C	35000.000									
\$										
CBAR*	5000									
* 5000S	0.0									* 5000S
* 5000T										* 5000T
* 5000U										* 5000U

FIGURE 2-12. MSC/NASTRAN INPUT BULK DATA DECK ECHO (SHEET 4 OF 11)

INITIAL CONDITION STATIC SOLUTION

INPUT BULK DATA DECK ECHO										
1	2	3	4	5	6	7	8	9	10	
PBAR*	5000	5000	5000	5000	29.50000000	23250.00000000*	5000A			
* 5000A	58000.00000000	81250.00000000	5000	5000	3800000.00					
MAT1*	5000	5000	10000000.00							
* 5000B										
* 5000C	35000.000	34000.000	17000.000							
\$										
CBAR*	6000	6000	6000	6000	700					
* 6000S	0.0	-1.000000000000	0.0							
* 6000T										
* 6000U										
PBAR*	6000	6000	6000	6000	28.50000000	28500.00000000*	6000A			
* 6000A	68000.00000000	96500.00000000								
MAT1*	6000	10000000.00								
* 6000B										
* 6000C	35000.000	34000.000	17000.000							
\$										
CBAR*	7000	7000	7000	7000	800					
* 7000S	0.0	-1.000000000000	0.0							
* 7000T										
* 7000U										
PBAR*	7000	7000	7000	7000	24.00000000	31000.00000000*	7000A			
* 7000A	57000.00000000	88000.00000000								
MAT1*	7000	10000000.00								
* 7000B										
* 7000C	35000.000	34000.000	17000.000							
\$										
CBAR*	8000	8000	8000	8000	900					
* 8000S	0.0	-1.000000000000	0.0							
* 8000T										
* 8000U										
PBAR*	8000	8000	8000	8000	18.50000000	16750.00000000*	8000A			
* 8000A	28000.00000000	44750.00000000								
MAT1*	8000	10000000.00								
* 8000B										
* 8000C	35000.000	34000.000	17000.000							
\$										
CBAR*	9000	9000	9000	9000	1000					
* 9000S	0.0	-1.000000000000	0.0							
* 9000T										
* 9000U										
PBAR*	9000	9000	9000	9000	12.50000000	4750.00000000*	9000A			
* 9000A	45000.00000000	49750.00000000								
MAT1*	9000	10000000.00								
* 9000B										
* 9000C	35000.000	34000.000	17000.000							
\$										
CBAR*	10000	10000	10000	500	1101					
* 10000S	-0.931764722649	0.363062669031	0.0							
* 10000T										
* 10000U										

FIGURE 2-12. MSC/NASTRAN INPUT BULK DATA DECK ECHO (SHEET 5 OF 11)

INPUT BULK DATA DECK ECHO

1	2	3	4	5	6	7	8	9	10
PBAR*	10000	10000	10000	10000	54.00000000	114000.00000000	100000		
MAT1*	10000	10000	100000000.00	38000000.0					
\$	35000.000	34000.000	17000.000						
CBAR*	11000	11000	1101	1200					
\$	11000S	-0.89091086066	-0.454177955109	0.0					
PBAR*	11000	11000	11000	11000	63.20000000	102000.00000000	11000A		
MAT1*	11000	11000	100000000.00	38000000.00					
\$	35000.000	34000.000	17000.000						
CBAR*	12000	12000	1200	1300					
\$	12000S	-0.86784592474	-0.49663305392	0.0					
PBAR*	12000	12000	12000	12000	56.30000000	58000.00000000	12000A		
MAT1*	12000	12000	100000000.00	38000000.00					
\$	35000.000	34000.000	17000.000						
CBAR*	13000	13000	1300	1400					
\$	13000S	-0.832330947833	-0.554278985060	0.0					
PBAR*	13000	13000	13000	13000	40.70000000	21000.00000000	13000A		
MAT1*	13000	13000	100000000.00	38000000.00					
\$	35000.000	34000.000	17000.000						
CBAR*	14000	14000	1400	1501					
\$	14000S	-0.841546482505	-0.540184707099	0.0					
PBAR*	14000	14000	14000	14000	20.00000000	8000.00000000	14000A		
MAT1*	14000	14000	100000000.00	38000000.00					
\$	35000.000	34000.000	17000.000						
CBAR*	15000	15000	1201	1601					
\$	15000S	0.001134791926	0.999999356123	0.0					

FIGURE 2-12. MSC/NASTRAN INPUT BULK DATA DECK ECHO (SHEET 6 OF 11)

INPUT BULK DATA DECK ECHO										
1	2	3	4	5	6	7	8	9	10	
PBAR*	15000									
* 15000A	732.00000000	220.80000000	15000		8.00000000		100.00000000*	15000A		
MAT1*	15000	10500000.00								
* 15000B										
* 15000C	47000.000	39000.000					0.100000000000*	15000C		
\$										
CBAR*	16000		16000		1401		1701			
* 16000S	0.005384743970	0.99985502161	0.0							
* 16000T										
* 16000U										
PBAR*	16000									
* 16000A	732.00000000	220.80000000	16000		8.00000000		100.00000000*	16000A		
MAT1*	16000	10500000.00								
* 16000B										
* 16000C	47000.000	39000.000					0.100000000000*	16000C		
\$										
CBAR*	17000		17000		1102		1800			
* 17000S	0.0	-0.999977553648								
* 17000T										
* 17000U										
PBAR*	17000									
* 17000A	239.00000000	150.00000000	17000		0.29919509		239.00000000*	17000A		
MAT1*	17000	30000000.00								
* 17000B										
* 17000C	75000.000	75000.000					0.100000000000*	17000C		
\$										
CBAR*	18000		18000		1103		1800			
* 18000S	0.0	-0.999977553648								
* 18000T										
* 18000U										
PBAR*	18000									
* 18000A	239.00000000	150.00000000	18000		0.01000000		239.00000000*	18000A		
MAT1*	18000	30000000.00								
* 18000B										
* 18000C	75000.000	75000.000					0.100000000000*	18000C		
\$										
CBAR*	19000		19000		201		1900			
* 19000S	0.0	-1.000000000000	0.0							
* 19000T										
* 19000U										
PBAR*	19000									
* 19000A	16.25000000	2.50000000	19000		0.05243324		16.25000000*	19000A		
MAT1*	19000	30000000.00								
* 19000B										
* 19000C	75000.000	75000.000					0.100000000000*	19000C		
\$										
CBAR*	20000		20000		600		1200			
* 20000S	-0.929399243434	0.369075935688	0.0							
* 20000T										
* 20000U										

FIGURE 2-12. MSC/NASTRAN INPUT BULK DATA DECK ECHO (SHEET 7 OF 11)

LT. SAMPLE DATA
21 MASS/28 BEAM TEST CASE ONLY-NOT VALID AIRPLANE MODEL

INITIAL CONDITION STATIC SOLUTION

INPUT BULK DATA DECK ECHO										
1	2	3	4	5	6	7	8	9	10	
PBAR*	20000	20000	4800.00000000	20000	40.70000000	21000.00000000*	20000A			
* 20000A	20000.00000000	20000	10000000.00	3800000.00						
MAT1*	20000B	20000	34000.000	17000.000						
* 20000B	35000.000	34000.000								
* 20000C	21000	21000	900	1400						
CBAR*	21000S	-0.879345610002	0.476184101131	0.0						
* 21000S	21000T	6								
* 21000T	21000U									
PBAR*	21000A	21000	4800.00000000	21000	40.70000000	21000.00000000*	21000A			
* 21000A	2000.00000000	2100J	10000000.00	3800000.00						
MAT1*	21000B	21000	34000.000	17000.000						
* 21000B	35000.000	34000.000								
* 21000C	22000	22000	1200	1199						
CBAR*	22000S	1.000000000000	0.000000000000	0.0						
* 22000S	22000T									
* 22000T	22000U									
PBAR*	22000A	22000	4800.00000000	22000	40.70000000	21000.00000000*	22000A			
* 22000A	2000.00000000	22000	10000000.00	3800000.00						
MAT1*	22000B	22000	34000.000	17000.000						
* 22000B	35000.000	34000.000								
* 22000C	23000	23000	200	2000						
CBAR*	23000S	0.0	1.000000000000	0.0						
* 23000S	23000T									
* 23000T	23000U									
PBAR*	23000A	23000	0.10178943	0.50000000*	23000A					
* 23000A	0.50000000	23000	10000000.00	4000000.00						
MAT1*	23000B	23000	16000.000	17000.000						
* 23000B	16000.000	16000.000								
* 23000C										
\$										
\$										
\$										
\$										
DRI MASSES CONNECTED WITH RBAR ELEMENTS										
RBAR	24000	200	2100	123456						
CBAR*	25000	25000	1500							
* 25000S	0.730502420322	0.682910106752	0.0							
* 25000T										
* 25000U										
PBAR*	25000A	25000	0.0	25000	0.0					
* 25000A	0.0	25000	10000000.00	3800000.00						
MAT1*	25000B	25000	34000.000	17000.000						
* 25000B	35000.000	34000.000								
* 25000C										
\$										
\$										
\$										
\$										

FIGURE 2-12. MSC/NASTRAN INPUT BULK DATA DECK ECHO (SHEET 8 OF 11)

INITIAL CONDITION STATIC SOLUTION

INPUT BULK DATA DECK ECHO										
1	2	3	4	5	6	7	8	9	10	
CBAR*	26000		26000	0.0	1502		1602			
* 26000S	0.750502420322	0.682910106752	0.0							
* 26000T										
* 26000U										
PBAR*	26000		26000	0.0	0.0					
* 26000A	0.0		0.0							
MAT1*	26000		10000000.00	3800000.00						
* 26000B							0.100000000000000000			
* 26000C	35000.000		34000.000	17000.000						
\$										
CBAR*	27000		27000	1500			1499			
* 27000S	1.0000000000000000	0.0000000000000000	0.0							
* 27000T										
* 27000U										
PBAR*	27000		27000	0.0						
* 27000A	1200.0000000000000000		2700.0000000000000000				8000.0000000000000000			
MAT1*	27000		10000000.00	3800000.00						
* 27000B							0.100000000000000000			
* 27000C	35000.000		34000.000	17000.000						
\$										
CBAR*	28000		28000	1502			1498			
* 28000S	1.0000000000000000	0.0000000000000000	0.0							
* 28000T										
* 28000U										
PBAR*	28000		28000	20.0000000000000000						
* 28000A	1200.0000000000000000		2700.0000000000000000				8000.0000000000000000			
MAT1*	28000		10000000.00	3800000.00						
* 28000B							0.100000000000000000			
* 28000C	35000.000		34000.000	17000.000						
\$										
MISCELLANEOUS CARDS										
EIGR	999	MGIV								
+EIGR	MAX									
FORCE AND MOMENT CARDS, BASED ON FINET CALCS										
FORCE*	1	100					1.0			
* 1000M	-7.56785966	0.0				-722.35195283				
MOMENT*	2	100								
* 1000N	0.0	74.8788473				0.0				
FORCE*	1	200					1.0			
* 2000M	-31.55523283	0.0				-4095.04371998				
MOMENT*	2	200								
* 2000N	0.0	561.5913546				0.0				
FORCE*	1	300					1.0			
* 3000M	-22.99168396	0.0				-6531.19035496				
MOMENT*	2	300								
* 3000N	0.0	181.4595265				0.0				

FIGURE 2-12. MSC/NASTRAN INPUT BULK DATA DECK ECHO (SHEET 9 OF 11)

INITIAL CONDITION STATIC SOLUTION

		INPUT		BULK DATA		DECK		ECHO	
1	2	3	4	5	6	7	8	9	10
FORCE*	1	..	400				1.0	*	4000M
MOMENT*	2	5.84772882	0.0		-4032.34379398				
FORCE*	1	..	400				1.0	*	4000N
MOMENT*	2	0.0	124.8885574		0.0				
FORCE*	1	..	500				1.0	*	5000M
MOMENT*	2	70.60230249	0.0		-6685.78934577				
FORCE*	1	..	500				1.0	*	5000N
MOMENT*	2	0.0	235.2506184		0.0				
FORCE*	1	..	600				1.0	*	6000M
MOMENT*	2	42.33434369	0.0		-2872.19975973				
FORCE*	1	..	600				1.0	*	6000N
MOMENT*	2	0.0	224.6365418		0.0				
FORCE*	1	..	700				1.0	*	7000M
MOMENT*	2	59.41232873	0.0		-3344.87377537				
FORCE*	1	..	700				1.0	*	7000N
MOMENT*	2	0.0	262.0759655		0.0				
FORCE*	1	..	800				1.0	*	8000M
MOMENT*	2	83.87946652	0.0		-4482.06723327				
FORCE*	1	..	800				1.0	*	8000N
MOMENT*	2	0.0	336.9548127		0.0				
FORCE*	1	..	900				1.0	*	9000M
MOMENT*	2	61.30714759	0.0		-2573.72885512				
FORCE*	1	..	900				1.0	*	9000N
MOMENT*	2	0.0	78.2259318		0.0				
FORCE*	1	..	1000				1.0	*	10000M
MOMENT*	2	27.38244991	0.0		-11756.62817664				
FORCE*	1	..	1000				1.0	*	10000N
MOMENT*	2	0.0	202.1354482		0.0				
FORCE*	1	..	1100				1.0	*	11000M
MOMENT*	2	23.12541991	103.21494745		5960.50952114				
FORCE*	1	..	1100				1.0	*	11000N
MOMENT*	2	-14.5761285	518.8725333		6.2085507				
FORCE*	1	..	1200				1.0	*	12000M
MOMENT*	2	-113.48138880	368.30966802		18339.92339842				
FORCE*	1	..	1200				1.0	*	12000N
MOMENT*	2	-22.8769999	459.2326870		9.4854969				
FORCE*	1	..	1300				1.0	*	13000M
MOMENT*	2	-167.47482007	479.82881212		16214.98538780				
FORCE*	1	..	1300				1.0	*	13000N
MOMENT*	2	-12.6374941	197.1100875		5.4498769				
FORCE*	1	..	1400				1.0	*	14000M
MOMENT*	2	-81.06087995	457.28347940		14133.50024522				
FORCE*	1	..	1400				1.0	*	14000N
MOMENT*	2	-8.3753450	96.7618458		4.3561419				
FORCE*	1	..	1500				1.0	*	15000M
MOMENT*	2	-33.41324906	106.98780051		4729.90095725				
FORCE*	1	..	1500				1.0	*	15000N
MOMENT*	2	-1.4133070	33.7559939		0.9256609				
FORCE*	1	..	1600				1.0	*	16000M
MOMENT*	2	24.83744530	-20.57526086		-5010.13312244				

FIGURE 2-12. MSC/NASTRAN INPUT BULK DATA DECK ECHO (SHEET 10 OF 11)

INITIAL CONDITION STATIC SOLUTION

[illegible]

INPUT BULK DATA CARD COUNT = 536

FIGURE 2-12. MSC/NASTRAN INPUT BULK DATA DECK ECHO (SHEET 11 OF 11)

input data set, using the following NASTRAN elements.

- GRID points
- CBAR bar elements (with PBAR properties and MAT1 materials)
- RBAR rigid bar elements
- FORCE and MOMENT cards for applied loads

Although only a linear model is formed, the following KRASH85 nonlinearities are included in the NASTRAN model:

- Oleo beam elements (initial position must be fully extended)
- Unsymmetrical beam elements

A nonlinear KRASH model is acceptable (KR tables), as long as the initial conditions are in the linear region. The executive and case control decks, plus the bulk data deck, are all contained in data set XYZ.NASBLK.DATA, which is generated automatically by program KRASH1C.

2.3.2.4 Sorted Bulk Data Deck Echo

This is just an alphabetically sorted version of the bulk data deck shown in figure 2-12. The last page of this is shown in figure 2-13. The EPSILON value shown is a measure of the error in the static solution. Any value less than E-7 is acceptable. Generally speaking, any significant error in the model will result in a very large value for EPSILON (>0.1) or will cause the NASTRAN solution to terminate with an error message.

2.3.2.5 Displacement Vector

Figure 2-14 shows a sample of the displacement vector output. These data represent the desired solution. The three translations and rotations at each grid point in the NASTRAN model are shown. The sign convention for these displacements/rotations within the NASTRAN model is as follows:

- T1 Positive deflection up, inches
- T2 Positive deflection right, inches

- T3 Positive deflection up, inches
- R1 Positive rotation left wing down, radians
- R2 Positive rotation nose up, radians
- R3 Positive rotation nose left, radians

All deflections/rotations are measured in an axis system that is parallel to the c.g. coordinate system defined in Section 2.2.

The grid point identifications within NASTRAN are related to the KRASH85 mass and mode points as follows:

Node point (I, M) becomes grid point $(100 \cdot I + M)$ e.g. Node point 11, 2 becomes grid point 1102. Mass point 5 becomes grid point 500.

In figure 2-14, grid points 1199, 1498 and 1499 do not correspond to any node points in the KRASH model. In the KRASH model there are two transverse beams attached to mass 15 and one to mass 12; i.e., beams which connect laterally between mass 15 (and 12) and a phantom (unnumbered) point at the same location on the opposite side of the airplane. For these lateral beams, a grid point on the airplane plane of symmetry ($y = 0$) is established in the NASTRAN model in order to constrain the deflections of lateral beams. Grid points 1199, 1498, and 1499 are all such constrained grid points.

The deflections and rotations for grid point 500 (mass point 5) are all zero. This is because mass point 5 was specified by the user to be the constraint point in the model. This was done by inputting NBAL = 5 on card 60 of the input format (figure 2-3). This can be seen on card sequence number 90 in the input data echo for this sample case (figure 2-8).

2.3.2.6 Load Vector

Figure 2-15 shows the vector of applied loads for the sample case. These are the NASTRAN input net loads generated by KRASHIC in subroutine NETFOR. The sign convention for these loads is the same as for the displacements, as defined in the previous section. The loads shown for grid points 201, 1102, 1498 and 1502 are the result of using FORCE1 type cards in the

LT. SAMPLE DATA
21 MASS/28 BLAH TEST CASE ONLY-NOT VALID AIRPLANE MODEL

INITIAL CONDITION STATIC SOLUTION

CARD	1	2	3	4	5	6	7	8	9	10
COUNT										
451-	PBAR	*28000								
452-		* 28000A1200.000000000	2700.000000000							
453-	PLOTTEL	201	200	201						
454-	PLOTTEL	501	500	501						
455-	PLOTTEL	1101	1100	1101						
456-	PLOTTEL	1102	1100	1102						
457-	PLOTTEL	1103	1100	1103						
458-	PLOTTEL	1201	1200	1201						
459-	PLOTTEL	1401	1400	1401						
460-	PLOTTEL	1501	1500	1501						
461-	PLOTTEL	1502	1500	1502						
462-	PLOTTEL	1601	1600	1601						
463-	PLOTTEL	1602	1600	1602						
464-	PLOTTEL	1701	1700	1701						
465-	RBAR	201	200	201	123456					
466-	RBAR	501	500	501	123456					
467-	RBAR	1101	1100	1101	123456					
468-	RBAR	1102	1100	1102	123456					
469-	RBAR	1103	1100	1103	123456					
470-	RBAR	1201	1200	1201	123456					
471-	RBAR	1401	1400	1401	123456					
472-	RBAR	1501	1500	1501	123456					
473-	RBAR	1502	1500	1502	123456					
474-	RBAR	1601	1600	1601	123456					
475-	RBAR	1602	1600	1602	123456					
476-	RBAR	1701	1700	1701	123456					
477-	RBAR	24000	200	2100	123456					
	ENDDATA									

TOTAL COUNT = 478

*** USER INFORMATION MESSAGE 3035 FOR DATA BLOCK KLL

LOAD SEQ. NO.	EPSILON	STRAIN	ENERGY
1	-1.1010772E-13		1.9329606E+05

EPSILONS LARGER THAN 0.001 ARE FLAGGED WITH ASTERISKS

FIGURE 2-13. MSC/NASTRAN SORTED BULK DATA DECK

DISPLACEMENT VECTOR

POINT ID.	TYPE	T1	T2	T3	R1	R2	R3
100	G	-3.089143E-02	0.0	-9.927106E-01	0.0	-2.240265E-03	0.0
200	G	-2.848941E-02	0.0	-7.68377E-01	0.0	-2.228401E-03	0.0
201	G	1.302763E-01	0.0	-8.132805E-01	0.0	-2.228401E-03	0.0
300	G	-7.956203E-03	0.0	-4.23564E-01	0.0	-2.016658E-03	0.0
400	G	-3.881565E-03	0.0	-1.467094E-01	0.0	-1.310210E-03	0.0
500	G	0.0	0.0	0.0	0.0	0.0	0.0
501	G	0.0	0.0	0.0	0.0	0.0	0.0
600	G	3.899802E-04	0.0	-1.395649E-01	0.0	1.905725E-03	0.0
700	G	-1.741050E-02	0.0	-3.224221E-01	0.0	2.646156E-03	0.0
800	G	1.960022E-02	0.0	-8.574673E-01	0.0	3.925506E-03	0.0
900	G	1.623366E-01	0.0	-1.646018E+00	0.0	5.791202E-03	0.0
1000	G	4.121324E-01	0.0	-2.947553E+00	0.0	6.380439E-03	0.0
1100	G	-2.376698E-02	-6.204827E-02	4.549806E-01	-6.692734E-03	-2.201433E-03	-5.605535E-04
1101	G	-1.923044E-02	-6.048078E-02	3.946607E-01	-6.692734E-03	-2.201433E-03	-5.605535E-04
1102	G	-1.296102E-02	-1.657880E-01	7.333746E-01	-6.692734E-03	-2.201433E-03	-5.605535E-04
1103	G	-1.296102E-02	-1.657880E-01	7.333746E-01	-6.692734E-03	-2.201433E-03	-5.605535E-04
1199	G	-9.159946E-02	0.0	5.671601E-01	0.0	-6.671559E-03	0.0
1200	G	-2.183176E-01	4.138304E-02	2.341775E+00	-1.306023E-02	-6.671559E-03	-9.325789E-04
1201	G	-2.439480E-01	3.842933E-02	2.721844E+00	-1.306023E-02	-6.671559E-03	-9.325789E-04
1300	G	-6.008078E-01	3.054584E-01	6.170222E+00	-2.241259E-02	-1.032131E-02	-1.681531E-03
1400	G	-1.368588E+00	6.399867E-01	1.084582E+01	-2.562689E-02	-7.394198E-03	-5.296092E-03
1401	G	-1.022665E+00	2.900504E-01	9.660528E+00	-2.562689E-02	-7.394198E-03	-5.296092E-03
1498	G	-6.724794E-01	0.0	8.267691E+00	0.0	-9.067751E-03	0.0
1499	G	-6.724794E-01	0.0	8.267691E+00	0.0	-9.067751E-03	0.0
1500	G	-2.495204E+00	4.342735E-01	1.459584E+01	-1.709927E-02	-9.067751E-03	-4.925180E-03
1501	G	-2.554648E+00	3.717274E-01	1.491737E+01	-1.709927E-02	-9.067751E-03	-4.925180E-03
1502	G	-2.495204E+00	4.342735E-01	1.459584E+01	-1.709927E-02	-9.067751E-03	-4.925180E-03
1600	G	-2.893808E-01	-2.893808E-01	1.937816E+00	-1.295898E-02	-9.379067E-03	-1.573276E-03
1601	G	-2.385539E-01	1.247806E-01	2.086101E+00	-1.295898E-02	-9.379067E-03	-1.573276E-03
1602	G	7.919782E-02	-2.893808E-01	1.937816E+00	-1.295898E-02	-9.379067E-03	-1.573276E-03
1700	G	-6.952541E-01	-3.463942E-02	8.834657E+00	-2.537073E-02	-9.936508E-03	-5.952671E-03
1701	G	-1.014149E+00	6.997894E-01	8.967865E+00	-2.537073E-02	-9.936508E-03	-5.952671E-03
1800	G	1.832867E-01	-7.628582E-01	6.224991E-01	-6.689236E-03	-2.204064E-03	-5.605265E-04
1900	G	2.696309E-01	0.0	-8.798568E-01	0.0	-2.22161E-03	0.0
2000	G	-9.809846E-02	0.0	-8.621072E-01	0.0	-4.137866E-03	0.0
2100	G	-7.305723E-02	0.0	-7.669372E-01	0.0	-2.228401E-03	0.0

FIGURE 2-14. MSC/NASTRAN DISPLACEMENT VECTOR

INITIAL CONDITION STATIC SOLUTION

POINT ID.	TYPE	LOAD VECTOR						
		T1	T2	T3	R1	R2	R3	
100	G	-7.567860E+00	0.0	-7.223518E+02	0.0	7.487885E+01	0.0	
200	G	-3.155522E+01	0.0	-4.095044E+03	0.0	5.615913E+02	0.0	
201	G	-3.488073E+00	0.0	1.500496E+03	0.0	0.0	0.0	
300	G	-2.299168E+01	0.0	-6.531187E+03	0.0	1.814595E+02	0.0	
400	G	5.847729E+00	0.0	-4.032344E+03	0.0	1.248885E+02	0.0	
500	G	7.060229E+01	0.0	-6.685789E+03	0.0	2.352506E+02	0.0	
600	G	4.233434E+01	0.0	-2.872200E+03	0.0	2.246365E+02	0.0	
700	G	5.941232E+01	0.0	-3.344874E+03	0.0	2.620759E+02	0.0	
800	G	8.387946E+01	0.0	-4.482066E+03	0.0	3.369546E+02	0.0	
900	G	6.130714E+01	0.0	-2.573729E+03	0.0	7.822592E+01	0.0	
1000	G	2.738245E+01	0.0	-1.175662E+04	0.0	2.021354E+02	0.0	
1100	G	2.312541E+01	1.032149E+02	5.960508E+03	-1.457613E+01	5.188723E+02	6.208550E+00	
1102	G	-2.228247E+01	6.777931E+01	1.011575E+04	0.0	0.0	0.0	
1200	G	-1.134814E+02	3.683096E+02	1.833992E+04	-2.287700E+01	4.592327E+02	9.485497E+00	
1300	G	-1.674748E+02	4.798286E+02	1.621498E+04	-1.263749E+01	1.971101E+02	5.449877E+00	
1400	G	-8.106087E+01	4.572834E+02	1.413350E+04	-8.375344E+00	9.676184E+01	4.356141E+00	
1498	G	0.0	-4.053146E+04	0.0	0.0	0.0	0.0	
1500	G	-3.341324E+01	1.069878E+02	4.729898E+03	-1.413306E+00	3.375598E+01	9.256608E-01	
1502	G	0.0	4.053146E+04	0.0	0.0	0.0	0.0	
1600	G	2.483743E+01	-2.057526E+01	-5.010133E+03	-2.410580E+02	9.622586E+01	-9.971355E+03	
1700	G	4.936182E+01	-1.645123E+01	-4.784145E+03	-2.292634E+02	9.183818E+01	-9.968402E+03	
1800	G	3.607445E+01	-6.777931E+01	-1.200200E+04	-2.421910E-02	5.990373E+00	1.685480E-02	
1900	G	2.459549E+00	0.0	-1.681604E+03	0.0	5.615914E-01	0.0	
2000	G	-3.308795E+00	0.0	-4.859563E+02	0.0	1.871971E+00	0.0	

FIGURE 2-15. MSC/NASTRAN LOAD VECTOR

NASTRAN input. These cards apply a constant axial force between two defined grid points. The FORCE1 cards in the sample case are used to account for nonlinear effects in oleos and unsymmetrical beams. There are no externally applied loads at node points, only at mass points.

2.3.2.7 Forces of Single-Point Constraint

Figure 2-16 shows the NASTRAN output that summarizes the forces of single-point constraint. This shows the forces and moments that are applied at the model constraint points to balance the model. For point 500, constraints are specified in all six directions, so corresponding forces are output. Note that the loads for the symmetric degrees of freedom (T1, T3, R2) are all very small, indicating that a well balanced set of applied loads is being used as input. This is the result of including inertia relief loads in the calculated net loads used as input to NASTRAN. The constraint forces in the anti-symmetric directions (T2, R1, R3) result from the geometry of the model. A half-airplane model is used, and wing loads come into mass 5. The constraint loads shown correspond to the missing loads that the right wing would have supplied. The same is true for grid points 600 and 900. Grid points 1199, 1498 and 1499 are center-plane grids as explained in Section 2.3.2.5. The single-point constraint forces shown for these grid points are the reactions at the center of transverse beams in the KRASH model.

2.3.2.8 Forces in Bar Elements

Figure 2-17 illustrates the NASTRAN output that summarizes the bar element static loads. The sign conventions for these loads are shown in figure 2-18, along with the corresponding KRASH85 beam element sign conventions. The KRASH85 loads that correspond to the NASTRAN bar element loads shown in figure 2-17 are as follows:

NASTRAN LOAD	CORRESPONDING KRASH85 LOAD
M1A	-MZI
M2A	MYI
M1B	MZI
M2B	-MYI
S1	FYJ
S2	FZJ
FX	FXJ
T	MXJ

NASTRAN plane 1 corresponds to the KRASH85 x-y plane, plane 2 corresponds to the x-z plane. Comparison of the loads in figure 2-17 with the KRASH "STRAIN FORCES" output at time zero will show a very close agreement. Beams which lie entirely in the airplane plane of symmetry ($y = 0$ plane) are treated differently in NASTRAN and KRASH85. In NASTRAN, the loads are for a half-beam, while in KRASH85 they are for an entire beam. This applies to beams 1000-9000, 19000 and 23000 in figure 2-17. (The NASTRAN bar element numbers are 1000 times the corresponding KRASH85 beam element numbers.) Beam 24000 is missing in the NASTRAN model; this is a DRI element which is modeled as a RBAR rigid element in NASTRAN.

2.3.2.9 Element Strain Energies

Figure 2-19 shows the NASTRAN output of bar element strain energies, in inch-pound units. Missing elements (1000, 25000, 26000) are those that have less than 0.001 percent of the total strain energy. These strain energies agree with the KRASH85 output at time zero, except for oleo and unsymmetrical beam elements. The use of FORCE1 cards in NASTRAN to model these nonlinear elements causes the strain energies calculated by NASTRAN to be incorrect. The KRASH85 strain energies for these elements are correct.

LT.SAMPLE.DAT
21 MASS/28 BEAM TEST CASE ONLY-NOT VALID AIRPLANE MODEL

INITIAL CONDITION STATIC SOLUTION

FORCES OF SINGLE-POINT CONSTRAINT

POINT ID.	TYPE	T1	T2	T3	R1	R2	R3
500	G	9.555735E-06	1.102906E+05	-1.647945E-03	1.158149E+07	4.253135E-01	-2.487183E+06
600	G	0.0	-2.197132E+04	0.0	1.765277E+06	0.0	1.538706E+06
900	G	0.0	4.899299E+04	0.0	2.010931E+06	0.0	3.964869E+03
1199	G	0.0	-6.197743E+04	0.0	9.611644E+05	0.0	7.206456E+05
1498	G	0.0	-7.681350E+04	0.0	2.772235E+05	0.0	5.323329E+05
1499	G	0.0	0.0	0.0	2.772235E+05	0.0	5.323329E+05

FIGURE 2-16. MSC/NASTRAN SINGLE-POINT CONSTRAINT FORCES

FORCES IN BAR ELEMENTS (C B A R)

ELEMENT ID.	BEND-MOMENT END-A		BEND-MOMENT END-B		- SHEAR -		AXIAL		TORQUE
	PLANE 1	PLANE 2	PLANE 1	PLANE 2	PLANE 1	PLANE 2	FORCE		
1000	0.0	-7.48788E+01	0.0	7.289244E+04	0.0	-7.223914E+02	-1.141130E-01		0.0
2000	0.0	7.469412E+04	0.0	9.423384E+05	0.0	-5.412230E+03	-2.830308E+02		0.0
3000	0.0	9.421569E+05	0.0	2.854471E+06	0.0	-1.195020E+04	-1.146083E+02		0.0
4000	0.0	2.854346E+06	0.0	6.051349E+06	0.0	-1.597832E+04	-3.910120E+02		0.0
5000	0.0	8.780416E+06	0.0	6.951579E+06	0.0	1.301489E+04	-2.433165E+04		0.0
6000	0.0	7.071534E+06	0.0	5.497074E+06	0.0	1.965147E+04	-2.519321E+04		0.0
7000	0.0	5.496812E+06	0.0	3.567440E+06	0.0	1.199094E+04	-2.774933E+04		0.0
8000	0.0	3.567104E+06	0.0	2.817684E+06	0.0	4.579750E+03	-2.801210E+04		0.0
9000	0.0	2.474320E+06	0.0	2.020132E+02	0.0	1.154472E+04	-2.222242E+03		0.0
10000	-3.186641E+06	-9.800311E+06	4.679865E+06	-3.733758E+06	-6.158012E+04	-4.748982E+04	8.935562E+04		6.447120E+06
11000	5.434646E+06	-6.946986E+06	3.117070E+05	-3.193432E+06	2.957813E+04	-2.167194E+04	1.118354E+05		5.954450E+05
12000	9.487483E+05	-4.564562E+06	2.698350E+06	-5.095244E+05	-9.511133E+03	-2.204306E+04	3.903610E+04		-3.209756E+05
13000	2.677814E+06	-5.073569E+05	3.958839E+06	2.801262E+05	-6.911449E+03	-4.248664E+03	3.846765E+04		-4.694600E+05
14000	4.043633E+06	6.632647E+05	-3.762905E+06	1.362978E+05	4.146377E+04	2.798940E+03	6.464662E+04		3.278991E+05
15000	8.070355E+03	4.640827E+05	9.633930E+03	8.282319E+04	-2.054707E+01	5.010164E+03	1.699046E+01		-1.118579E+05
16000	8.477410E+03	4.386772E+05	9.709035E+03	7.460462E+04	-1.618520E+01	4.784395E+03	-5.900237E+00		-3.064334E+02
17000	-5.631099E+02	-4.264045E+02	1.222204E-02	2.995131E+00	-6.319184E+00	-4.818592E+00	1.161406E+04		-2.658223E+02
18000	-5.631099E+02	-4.264045E+02	1.222204E-02	2.995131E+00	-6.319184E+00	-4.818592E+00	3.681768E+02		-2.852233E+02
19000	0.0	8.109880E+01	0.0	5.615880E-01	0.0	1.287221E+03	1.681605E+03		0.0
20000	1.520495E+06	-1.596292E+06	-5.776721E-01	6.527750E-01	5.198594E+03	-5.457746E+03	-2.170905E+04		7.100006E+05
21000	3.323657E-11	-1.931766E+06	-1.521906E-09	9.507744E+05	2.346161E-12	-4.348730E+03	5.568992E+04		6.557260E+05
22000	-7.206456E+05	-9.611644E+05	-7.206456E+05	-9.611643E+05	0.0	-9.094947E-13	-6.197740E+04		0.0
23000	0.0	9.780161E+01	0.0	-1.871973E+00	0.0	5.007499E+00	-4.859414E+02		0.0
25000	0.0	0.0	0.0	0.0	0.0	0.0	0.0		0.0
26000	0.0	0.0	0.0	0.0	0.0	0.0	0.0		0.0
27000	-5.323329E+05	-2.772235E+05	-5.323329E+05	-2.772234E+05	-1.080025E-12	-1.136868E-12	0.0		0.0
28000	-5.323329E+05	-2.772235E+05	-5.323329E+05	-2.772234E+05	-1.080025E-12	-1.136868E-12	-1.173449E+05		0.0

FIGURE 2-17. MSC/NASTRAN BAR ELEMENT FORCES

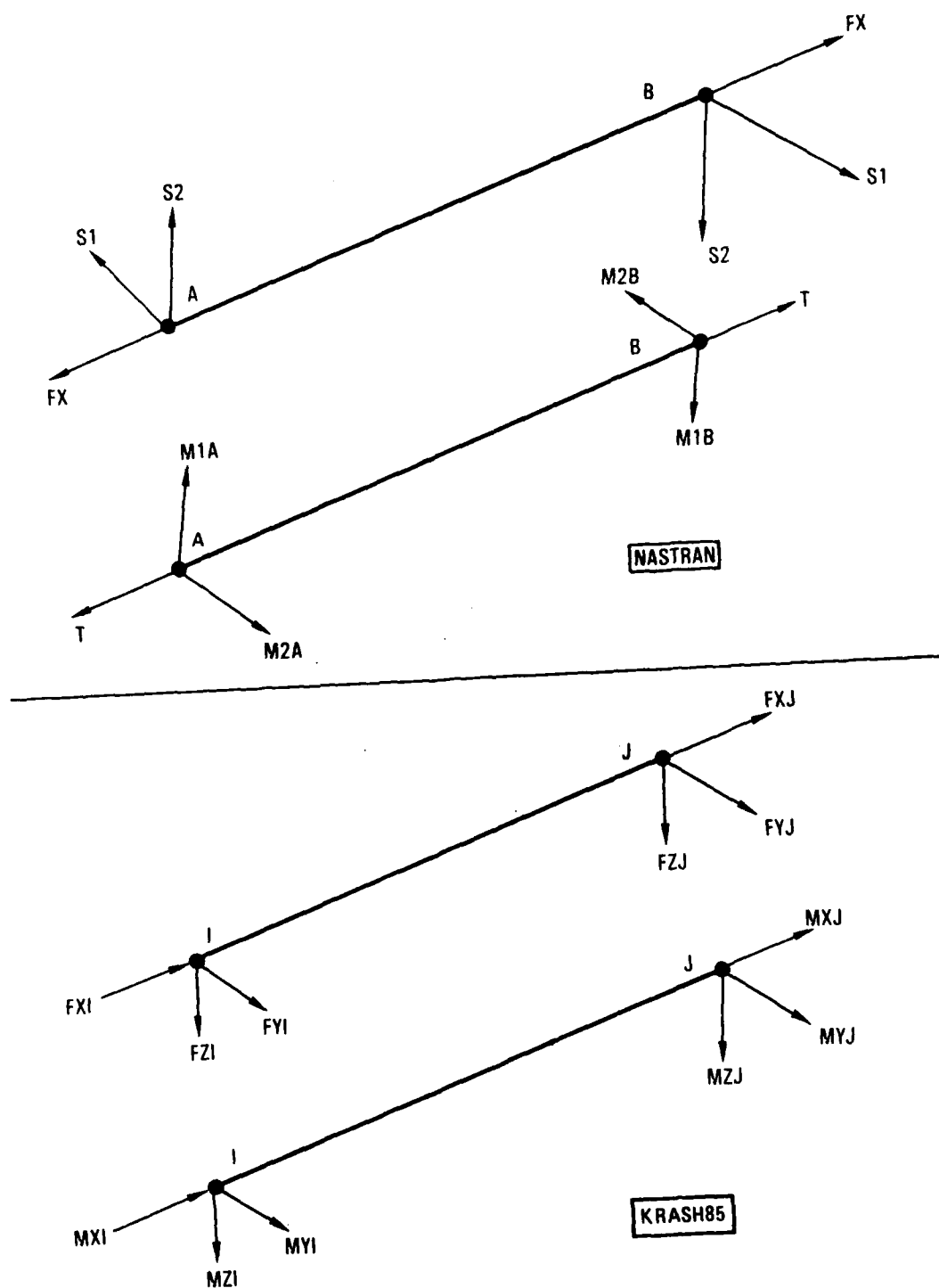


FIGURE 2-18. BAR ELEMENT FORCE SIGN CONVENTIONS, NASTRAN AND KRASH85

ELEMENT STRAIN ENERGIES

2-154

FIGURE 2-19. MSC/NASTRAN ELEMENT STRAIN ENERGIES

2.3.2.10 Grid Point Force Balance

Figure 2-20 shows the NASTRAN output that tabulates all the forces and moments acting at the grid points. The totals shown at each grid point are not always zero; the loads due to RBAR rigid bar elements are not included in the balance. Therefore, mass points which have node points connected to them, as well as the corresponding node points, will show nonzero total loads. (Grid points 200 and 201 in figure 2-20 for example.) Mass points without node points (such as 500 or 600) will show zero total loads. Due to this anomaly in the grid point force balance output, these data are only marginally useful.

2.3.3 KRASH85 Output

2.3.3.1 Initial Output

The initial output of KRASH85 is identical to that of KRASHIC, described in Section 2.3.1. These data were illustrated in figures 2-8 through 2-10. The only exceptions to this are the mass and node point coordinates, as well as the initial mass and node point deflections. The values shown in the KRASHIC input represent the values before the last iteration of KRASHIC/MSCTRAN. The values shown in the KRASH85 output are those following the last iteration. There will be slight differences in the deflections between those two outputs, unless a very large number of iterations are used (>10).

Figure 2-21 shows this section of the output from KRASH85. Note that the initial deflections and corresponding coordinate positions are slightly different from those shown in figure 2-9. As an example, the initial node point z deflection for node point 11, 1 changes from $-.3946611$ in figure 2-9 to $-.3946607$ in figure 2-21. These values represent before and after the tenth iteration. The corresponding node point z coordinates show no difference between figures 2-9 and 2-21, since the coordinate values are shown only to .001 inch. The differences are much finer than that.

Also, the initial deflections are in data set XYZ.NASOUT.DATA, which is always shown at the bottom of the ECHO of input data. If all deflections

in this data set agree between the KRASHIC and KRASH85 outputs, then further iterations cannot improve the accuracy of the initial conditions balance. If the two sets of data do differ, and the user is not satisfied with the quality of the initial balance, then further iterations could improve the initial balance.

KRASH85 includes some additional miscellaneous calculated data, in addition to that described for KRASHIC in Section 2.3.1.3. Figure 2-22 illustrates this output, which is calculated prior to time zero in KRASH85. These data include

- Beam uncoupled, undamped frequencies
- Beam damping constants
- Euler angles, beam IJ to airplane
- Load interaction curve load ratios (optional)

The beam frequencies output are the undamped, uncoupled individual beam frequencies associated with the six degrees of freedom of each beam. The frequencies listed under the headings (1), (2), and (3) correspond with the three translational degrees of freedom (x, y, z) and those listed under the heading (4), (5), and (6) correspond to the three rotational degrees of freedom (ϕ , θ , ψ). The frequencies are computed using equations 1-55(a) and 1-55(b) from Volume I, Section 1.3.5.3.6.

The frequency values summarized should be reviewed for indications of potential stability problems which may occur with the numerical integration routine used in the program. For example, high frequencies combined with a relatively coarse integration interval may result in numerical integration instabilities. In general, beam member frequencies should satisfy the following criteria:

- 1) Member frequencies < 500 Hz
- 2) The product of the maximum beam member frequency and the integration interval < 0.01

LT.SAMPLE DATA
21 MASS/28 BEAM TEST CASE ONLY-NOT VALID AIRPLANE MODEL
INITIAL CONDITION STATIC SOLUTION

		GRID POINT FORCE BALANCE									
POINT-ID	ELEMENT-ID	SOURCE	T1	T2	T3	R1	R2	R3			
100	1000	APP-LOAD	-7.567860E+00	0.0	-7.223516E+02	0.0	7.487835E+01	0.0			
100		BAR	7.567859E+00	0.0	-7.223516E+02	0.0	-7.487835E+01	0.0			
100		*TOTALS*	-1.546141E-11	0.0	-1.746230E-10	0.0	-1.536682E-08	0.0			
200	1000	APP-LOAD	-3.155522E+01	0.0	-4.095044E+03	0.0	5.615913E+02	0.0			
200		BAR	-7.567859E+00	0.0	-7.223516E+02	0.0	-7.289244E+04	0.0			
200	2000	BAR	4.346039E+01	0.0	5.419457E+03	0.0	7.469412E+04	0.0			
200	23000	BAR	-3.308794E+00	0.0	-4.859561E+02	0.0	-9.780161E+01	0.0			
200		*TOTALS*	1.028524E+00	0.0	1.161077E+02	0.0	2.265459E+03	0.0			
201	19000	APP-LOAD	-3.488073E+00	0.0	1.565496E+03	0.0	0.0	0.0			
201		BAR	2.459548E+00	0.0	-1.681604E+03	0.0	8.109880E+01	0.0			
201		*TOTALS*	-1.028524E+00	0.0	-1.161077E+02	0.0	8.109880E+01	0.0			
300	2000	APP-LOAD	-2.299168E+01	0.0	-6.531187E+03	0.0	1.814595E+02	0.0			
300		BAR	-4.346039E+01	0.0	-5.419457E+03	0.0	-9.423384E+05	0.0			
300	3000	BAR	6.645207E+01	0.0	1.195064E+04	0.0	9.421569E+05	0.0			
300		*TOTALS*	-1.421085E-12	0.0	-2.473826E-10	0.0	7.683411E-09	0.0			
400	3000	APP-LOAD	5.847729E+00	0.0	-4.032344E+03	0.0	1.248885E+02	0.0			
400		BAR	-6.645207E+01	0.0	-1.195064E+04	0.0	-2.854471E+06	0.0			
400	4000	BAR	6.060435E+01	0.0	1.598299E+04	0.0	2.854346E+06	0.0			
400		*TOTALS*	2.785328E-12	0.0	-1.164153E-10	0.0	1.024455E-08	0.0			
500	5000	F-OF-SPC	9.535735E-06	1.102906E+05	-1.647945E-03	1.158149E+07	4.253135E-01	-2.487183E+06			
500		APP-LOAD	7.060229E+01	0.0	-6.685789E+03	0.0	2.352506E+02	0.0			
500		BAR	-6.060435E+01	0.0	-1.598299E+04	0.0	-6.051349E+06	0.0			
500	5000	BAR	-2.312483E+04	0.0	-1.505520E+04	0.0	8.780416E+06	0.0			
500	10000	BAR	2.311484E+04	-1.102906E+05	3.772398E+04	-1.158149E+07	-2.729302E+06	2.487183E+06			
500		*TOTALS*	1.546141E-11	1.455192E-11	-2.910383E-11	-6.984919E-10	-2.328306E-10	-1.396984E-09			
600	6000	APP-LOAD	4.233434E+01	0.0	-2.872200E+03	0.0	2.246365E+02	0.0			
600		F-OF-SPC	0.0	-2.197132E+04	0.0	1.765277E+06	0.0	1.538706E+06			
600		BAR	2.312483E+04	0.0	1.505520E+04	0.0	-6.951579E+06	0.0			
600	6000	BAR	-2.629875E+04	0.0	-1.814537E+04	0.0	7.071534E+06	0.0			
600	20000	BAR	3.131584E+03	2.197132E+04	5.962367E+03	-1.765277E+06	-1.231791E+05	-1.538706E+06			
600		*TOTALS*	-3.365130E-11	4.547474E-12	-3.883542E-10	-2.328306E-10	2.124580E-08	0.0			
700	6000	APP-LOAD	5.941232E+01	0.0	-3.344874E+03	0.0	2.620759E+02	0.0			
700		BAR	2.629875E+04	0.0	1.814537E+04	0.0	-5.497074E+06	0.0			
700	7000	BAR	-2.635816E+04	0.0	-1.480050E+04	0.0	5.496812E+06	0.0			
700		*TOTALS*	5.820766E-11	0.0	1.527951E-09	0.0	3.725290E-09	0.0			
800	7000	APP-LOAD	8.387946E+01	0.0	-4.482066E+03	0.0	3.369546E+02	0.0			
800		BAR	2.635816E+04	0.0	1.480050E+04	0.0	-3.567440E+06	0.0			
800	8000	BAR	-2.644204E+04	0.0	-1.031843E+04	0.0	3.567104E+06	0.0			
800		*TOTALS*	1.455192E-11	0.0	-4.947651E-10	0.0	7.078052E-08	0.0			
900		F-OF-SPC	0.0	4.899299E+04	0.0	2.010931E+06	0.0	3.964869E+02			
900		APP-LOAD	6.130714E+01	0.0	-2.573729E+03	0.0	7.822592E+01	0.0			

FIGURE 2-20. MSC/NASTRAN GRID POINT FORCE BALANCE

2 1 -1.102762D-01 0.0 8.132805D-01

GENERALIZED SURFACE DATA

BETA = 0.0 DEGREES
XGIN = 0.0
ZGIN = 0.0

MASS DATA

WEIGHTS		MASS COORDINATES F.S.,B.,L.,M.L.				MASS MOMENTS OF INERTIA (LB-IN-SEC**2)			
I	N	X''	Y''	Z''		IX	IY	IZ	I
1	1.585000 03	1.98960 02	0.0	2.19007D 02		1.151400 04	4.000000 04	1.500000 04	1
2	9.064500 03	2.99972D 02	0.0	2.17933D 02		8.908000 04	3.000000 05	9.900000 04	2
3	1.53181D 04	4.59992D 02	0.0	2.08278D 02		1.627800 05	9.693500 04	1.030900 05	3
4	1.30960D 04	6.19996D 02	0.0	2.05853D 02		1.962700 05	6.67150D 04	7.938900 04	4
5	2.17526D 04	8.20000D 02	0.0	2.00200D 02		4.910600 05	1.256700 05	1.465100 05	5
6	7.90150D 03	9.60000D 02	0.0	2.12260D 02		8.138300 04	1.200000 05	2.000000 05	6
7	9.19070D 03	1.03998D 03	0.0	2.07578D 02		8.753600 04	1.400000 05	2.000000 05	7
8	9.93840D 03	1.20002D 03	0.0	2.24243D 02		8.809800 04	1.800000 05	3.000000 05	8
9	5.70200D 03	1.36006D 03	0.0	2.58354D 02		9.624900 04	4.178800 04	2.60390D 04	9
10	6.17520D 03	1.57041D 03	0.0	2.99352D 02		2.153000 05	1.07980D 05	1.586300 05	10
11	9.67060D 03	8.01276D 02	1.18362D 02	1.88755D 02		1.521300 04	1.38580D 05	3.600000 05	11
12	1.00656D 04	8.52082D 02	2.71759D 02	2.05442D 02		1.951000 04	1.228300 05	3.000000 05	12
13	5.28650D 03	9.42899D 02	4.30395D 02	2.26070D 02		7.271500 03	5.26190D 04	1.100000 05	13
14	3.75900D 03	1.04443D 03	5.82860D 02	2.54346D 02		4.408300 03	2.58230D 04	6.000000 04	14
15	1.54230D 03	1.11010D 03	7.40166D 02	2.69696D 02		1.670800 03	9.01370D 03	1.800000 04	15
16	5.40000D 03	7.19079D 02	3.21889D 02	1.67738D 02		3.65158D 03	2.57460D 04	2.93746D 04	16
17	5.15100D 03	9.02105D 02	5.51635D 02	1.96935D 02		3.71200D 03	2.45882D 04	2.81780D 04	17
18	1.92200D 03	8.87183D 02	1.32363D 02	9.13225D 01		3.71000D 03	1.600000 03	2.000000 03	18
19	2.38000D 02	2.79270D 02	0.0	8.41201D 01		2.400000 01	3.000000 02	5.000000 02	19
20	1.00000D 03	2.99902D 02	0.0	2.37838D 02		1.000000 03	1.000000 03	1.000000 03	20
21	1.00000D 03	2.99927D 02	0.0	2.37933D 02		1.000000 03	1.000000 03	1.000000 03	21

NODE POINT DATA

MASS N.P.		NODE POINT COORDINATES F.S.,B.,L.,M.L.			
I	N	X''	Y''	Z''	
5	1	7.75100D 02	4.80000D 01	1.81000D 02	
11	1	7.73881D 02	1.18360D 02	1.86695D 02	
11	2	8.86987D 02	1.31766D 02	1.80433D 02	
11	3	8.86987D 02	1.31766D 02	1.80433D 02	
12	1	8.11556D 02	3.21562D 02	2.02322D 02	
14	1	9.93477D 02	5.51310D 02	2.30161D 02	
15	1	1.14545D 03	7.40228D 02	2.76217D 02	
15	2	1.11010D 03	7.40166D 02	2.69696D 02	
16	1	7.35461D 02	3.21475D 02	2.01686D 02	
16	2	7.19079D 02	3.21889D 02	1.67738D 02	
17	1	9.17386D 02	5.50900D 02	2.29468D 02	
2	1	2.79130D 02	0.0	1.46687D 02	

EXTERNAL SPRING DATA

FIGURE 2-21. KRASH85 OUTPUT, INITIAL MASS/NODE POINT DEFLECTIONS (SHEET 1 OF 2)

MISS POSITION PLOTS

VEHICLE INITIAL CONDITIONS

VEHICLE TRANSLATIONAL VELOCITIES IN GROUND AXES (IN/SEC)
 VEHICLE ROTATIONAL VELOCITIES IN VEHICLE AXES (RAD/SEC)
 EULER ANGLES OF VEHICLE RELATIVE TO GROUND (RADIAN)

XGDOT	YGDOT	ZGDOT
P'	Q'	R'
PHI'	THETA'	PSI'
3.14000D 03	0.0	3.00000D 02
0.0	1.00000D-01	0.0
0.0	1.74500D-02	0.0

INITIAL MASS POINT DEFLECTIONS

I	DXAPI(I)	DYAPI(I)	DZAPI(I)	DPHAPI(I)	DTHAPI(I)	DPSAPI(I)	I
1	3.089143D-02	0.0	9.927106D-01	0.0	-2.240265D-03	0.0	1
2	2.84941D-02	0.0	7.668377D-01	0.0	-2.228401D-03	0.0	2
3	7.956203D-03	0.0	4.223564D-01	0.0	-2.016658D-03	0.0	3
4	3.881565D-03	0.0	1.467094D-01	0.0	-1.310210D-03	0.0	4
5	0.0	0.0	0.0	0.0	0.0	0.0	5
6	-3.89802D-04	0.0	1.395649D-01	0.0	1.905725D-03	0.0	6
7	1.741050D-02	0.0	3.224221D-01	0.0	2.646156D-03	0.0	7
8	-1.960022D-02	0.0	8.574673D-01	0.0	3.925506D-03	0.0	8
9	-1.623366D-01	0.0	1.646018D 00	0.0	5.791202D-03	0.0	9
10	-4.121324D-01	0.0	2.947553D 00	0.0	6.380439D-03	0.0	10
11	2.376698D-02	-6.204827D-02	-4.549806D-01	6.692734D-03	-2.201433D-03	5.605535D-04	11
12	2.183176D-01	4.138304D-02	-2.341775D 00	1.306023D-02	-6.671559D-03	9.325789D-04	12
13	6.008078D-01	3.054584D-01	-6.170222D 00	2.241259D-02	-1.032131D-02	1.681510D-03	13
14	1.368588D 00	6.399867D-01	-1.084582D 01	2.562689D-02	-7.394198D-03	5.246092D-03	14
15	2.495204D 00	4.342735D-01	-1.459584D 01	1.709927D-02	-9.067751D-03	4.925180D-03	15
16	-7.919782D-02	-2.893808D-01	-1.937816D 00	1.295898D 00	-9.379067D-03	1.573276D-03	16
17	6.952541D-01	-3.463942D-02	-8.834657D 00	2.537073D-02	-9.936508D-03	5.952671D-03	17
18	-1.832867D-01	-7.628582D-01	-6.224991D-01	6.689236D-03	-2.204064D-03	5.605265D-04	18
19	-2.696309D-01	0.0	8.798568D-01	0.0	-2.223161D-03	0.0	19
20	9.809846D-02	0.0	8.621072D-01	0.0	-4.137866D-03	0.0	20
21	7.305723D-02	0.0	7.669372D-01	0.0	-2.228401D-03	0.0	21

INITIAL NODE POINT DEFLECTIONS

I	M	DXNPAP	DYNPAP	DZNPAP
5	1	0.0	0.0	0.0
11	1	1.923044D-02	-6.048078D-02	-3.946607D-01
11	2	1.296102D-02	-1.657880D-01	-7.333746D-01
11	3	1.296102D-02	-1.657880D-01	-7.333746D-01
12	1	2.439480D-01	3.842933D-02	-2.721844D 00
14	1	1.022665D 00	2.900504D-01	-9.660528D 00
15	1	2.556648D 00	3.717274D-01	-1.491737D 01
15	2	2.405204D 00	4.342735D-01	-1.459584D 01
16	1	2.385539D-01	1.247806D-01	-2.086101D 00
16	2	-7.919782D-02	-2.893808D-01	-1.937816D 00
17	1	1.014149D 00	6.997894D-01	-8.967865D 00

FIGURE 2-21. KRASH85 OUTPUT, INITIAL MASS/NODE POINT DEFLECTIONS (SHEET 2 OF 2)

I	J	M	N	BEAM UNCOUPLED, UNDAMPED FREQUENCIES (CPS)															
				(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)
18	1	1	2	0	0	1.51530	02	1.76710	02	2.28740	02	9.61890	01	1.32740	02	1.68800	02	9.96840	03
	2	2	3	0	0	6.20940	01	4.63720	01	6.20540	01	3.53800	01	8.15030	01	7.33250	01	-2.38450	-04
	3	3	4	0	0	5.58170	01	4.17600	01	5.90580	01	2.95320	01	1.17390	02	7.79020	01		
	4	4	5	0	0	5.93890	01	2.88660	01	4.93660	01	2.50290	01	1.25710	02	6.75760	01		
	5	5	6	0	0	8.41600	01	5.82450	01	9.19950	01	3.97550	01	1.16730	02	6.27190	01		
19	6	6	7	0	0	1.27950	02	1.74950	02	2.70230	02	7.38880	01	1.63150	02	8.49800	01		
	7	7	8	0	0	7.81570	01	6.04740	01	8.20030	01	4.84600	01	9.54760	01	5.72400	01		
	8	8	9	0	0	7.81130	01	4.97570	01	6.43320	01	3.32420	01	1.01110	02	8.83900	01		
	9	9	10	0	0	6.20270	01	1.95450	01	6.01570	01	2.62210	01	1.18840	02	4.29040	01		
	10	10	11	0	0	7.85750	01	9.79010	01	3.65820	01	2.22970	01	6.55500	01	9.32240	01		
20	11	11	12	0	0	8.50520	01	6.83600	01	2.28470	01	1.62860	01	5.71830	01	6.05800	01		
	12	12	13	0	0	9.29170	01	5.61610	01	1.59870	01	1.33320	01	4.44000	01	6.31680	01		
	13	13	14	0	0	9.88560	01	4.19690	01	1.29520	01	1.37250	01	3.87190	01	5.46860	01		
	14	14	15	0	0	9.74550	01	3.58620	01	1.38890	01	1.63840	01	4.77360	01	5.59270	01		
	15	15	16	0	0	1.554160	01	8.91890	00	2.41310	01	9.67690	00	2.19440	01	7.23410	00		
21	16	16	17	0	0	1.704740	01	1.13430	01	3.06880	01	1.20040	01	2.85120	01	8.54390	00		
	17	17	18	0	0	4.53100	00	2.72290	01	2.72290	01	1.53560	01	7.17910	01	1.50030	02		
	18	18	19	0	0	4.53100	00	2.72290	01	2.72290	01	1.53560	01	7.17910	01	1.50030	02		
	19	19	20	0	0	1.42180	01	4.48780	01	4.48780	01	6.60200	00	7.25830	01	2.56530	02		
	20	20	21	0	0	5.54400	01	1.49150	01	4.60290	00	5.31740	00	1.69320	01	2.46270	01		
22	21	21	22	0	0	5.14780	01	6.11100	00	1.88590	00	6.77770	00	1.92190	01	4.20450	01		
	22	22	23	0	0	3.81420	01	5.52190	00	1.70410	00	3.72300	00	1.95440	01	1.61560	01		
	23	23	24	0	0	1.05370	01	4.06430	00	4.06430	00	7.17060	-01	2.25990	00	2.26880	00		
	24	24	25	0	0	8.42970	00	4.03540	00	4.03540	00	7.15350	-01	2.25450	00	2.26340	00		
	25	25	26	0	0	5.29410	01	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		
26	15	16	2	2	5.29410	01	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		

FIGURE 2-22. KRASH85 OUTPUT, ADDITIONAL MISCELLANEOUS CALCULATED DATA (SHEET 1 OF 3)

DAMPING TERMS (LB/IN/SEC, TRANSLATIONS (1)-(3) AND LB-IN-SEC, ROTATIONS (4)-(6))															
DAMPING TERMS				(1)-(6)											
I	J	M	N	(1)	(2)	(3)	(4)	(5)	(6)						
27	15	0	0	0	4.13890	01	1.93710	00	7.50220-01	6.24050	00	3.13410	01	2.46680	01
28	15	0	2	0	4.12890	01	1.92710	00	7.50220-01	6.24050	00	3.13410	01	2.46680	01
EULER ANGLES, BEAM IJ TO AIRPLANE (RADIANS)															
EULER ANGLES, BEAM IJ TO AIRPLANE				(RADIANS)											
I	J	M	N	THEIJOI(I)	PSIIJOI(I)										
1	1	2	0	0	-1.063430-02	3.141590	00								
2	2	3	0	0	-6.026620-02	3.141590	00								
3	3	4	0	0	-1.515070-02	3.141590	00								
4	4	5	0	0	-8.593360-02	3.141590	00								
5	5	6	0	0	-5.848200-02	3.141590	00								
6	7	8	0	0	-1.037580-01	3.141590	00								
8	8	9	0	0	2.099970-01	3.141590	00								
9	10	0	0	1	1.924930-01	3.141590	00								
10	5	11	0	1	-1.059200-01	-1.199240	00								
11	12	1	0	1	1.084520-01	-2.042250	00								
12	13	0	0	1	1.123760-01	-2.090740	00								
13	13	14	0	0	1.531520-01	-2.158290	00								
14	14	0	1	1	1.164320-01	-2.144500	00								
15	12	16	1	1	-8.354440-03	1.134790-03									
16	14	17	1	1	-9.102650-03	5.386770-03									
17	11	18	2	0	2.202230-03	-3.134890	00								
18	11	18	3	0	2.202230-03	-3.134890	00								
19	2	19	1	0	2.227300-03	3.141590	00								
20	6	12	0	0	-2.331520-02	-1.192780	00								
21	9	14	0	0	-6.046940-03	1.074800	00								
22	12	0	0	0	0.0	1.570400	00								
23	2	20	0	0	-3.497100-03	0.0									
24	2	21	0	0	-2.228400-03	0.0									

FIGURE 2-22. KRASH85 OUTPUT, ADDITIONAL MISCELLANEOUS CALCULATED DATA (SHEET 2 OF 3)

25	15	0	0	-1.76219D-01	8.19057D-01
26	15	16	2	-1.76219D-01	8.19057D-01
27	15	0	0	0.0	1.57080D 00
28	15	0	2	0.0	1.57080D 00

LOAD INTERACTION CURVE LOAD RATIOS

PROPORTION OF BEAM END LOADS
CURVE BEAM MAKING UP INTERACTION LOADS

CURVE NO.	BEAM NO.	I END	J END
1	1	-2.8207D-04	1.0003D 00
2	2	9.9982D-01	1.7804D-04
3	2	3.7490D-01	6.2510D-01
4	3	8.7495D-01	1.2505D-01
5	3	4.9996D-01	5.0004D-01
6	3	-2.4259D-05	1.0000D 00
7	4	9.9988D-01	1.9407D-05
8	5	2.7856D-06	1.0000D 00
9	6	1.0000D 00	-4.8753D-06
10	6	4.9989D-01	5.0011D-01
11	7	7.4995D-01	2.5005D-01
12	7	2.5006D-01	7.4994D-01
13	8	7.5019D-01	2.4981D-01
14	8	2.5032D-01	7.4968D-01
15	9	8.1014D-01	1.8986D-01

While these criteria are suggested as guidelines, their exceedance does not necessarily mean that instability problems will automatically occur.

Beam structural damping coefficients are computed within the program for each of the six beam degrees of freedom. The damping coefficients are computed from equations (1-54), Section 1.3.5.3.6, Volume 1.

These damping coefficients are printed only to provide a record of the actual data used in the calculations. The interpretation of the proper damping values should be based upon inspection of the damping ratios (actual damping/critical damping) summarized in the section entitled "INTERNAL BEAM DATA" (Section (2.3.3.2.2)). For typical aircraft constructions, damping ratios in the range of .01 to .10 are appropriate. Higher values should be used only to represent mechanical damping devices, such as hydraulic or friction dampers in landing gears or viscoelastic engine mounts. Values greater than .05 are probably only justified as representative of the friction damping associated with relative motions of riveted and bolted structure under conditions of severe loading and deformation.

The Euler angles define the initial orientation of the beam axes relative to the airplane, according to the convention shown in figure 2-5. These angles should be interpreted in the following manner. Assume the beam axes are oriented such that x is forward, y to the right and z down. Then rotate Ψ radians about the z axis, positive nose right, forming a new set of x' and y' axes. Then rotate Θ radians about the new y' axis, positive nose up. This final position defines the orientation of the beam axes with respect to the airplane. For vertical beams, which are denoted by $VBM=1$ in the beam data formatted output, the above procedure is followed with one exception. The initial orientation is such that the x axis is positive up, y axis positive right and z axis positive forward.

It should be noted that during the time history analysis, these angles vary with time and are part of the print output. Any question regarding the current beam orientations should be resolved by examining the current values of the beam orientation Euler angles. These are interpreted the same as the preceding discussion, except that the initial starting orientation is the

ground axes rather than the airplane axes. Since the initial attitude of the vehicle may not be parallel to the ground axes (generally it is not), the time zero value of the beam orientation Euler angles may differ from the angles listed in the MODEL PARAMETERS section of the output. The latter is provided as a definition of beam axes orientations that is independent of vehicle initial conditions (and hence represents a true model parameter), whereas the time varying values represent the actual beam orientation during the analysis.

The load interaction curve load ratios tabulate what proportion of the I and J end beam loads are used to calculate the intermediate loads at the location specified for each load interaction curve.

2.3.3.2 Time History Output

This section of the output prints the time varying response quantities at each print time interval, including time zero. This output consists of the following groups of data:

- Title cards
- Analysis time
- Mass and node point displacements, velocities and accelerations in six directions for all NM lumped masses and NNP node points, in mass axes and ground axes
- Mass impulses (G-sec) based on filtered accelerations
- Internal beam strain forces, total forces (strain + damping) in both beam and mass axes and displacements in six directions for all NB internal beams
- External spring compressions, ground deflections, axial loads, and ground contact loads (3 directions) in ground axes and mass axes for all NSP external springs
- DRI number for all DRI beam elements
- Overall vehicle c.g. translational velocity (3 directions)
- Volume change data, including current volume, current volume/initial volume, and the changes in length of the three lengths of the volume (optional)

- Energy distribution by type
- Energy distribution by mass (kinetic and potential), beam (strain, damping) and spring (crushing, friction)
- Mass energy deviation
- Stress output for internal beam elements, including ratios of current stress/failure stress for two failure theories
- At $t=0$ only, the differences between actual initial mass accelerations and the theoretically exact values, for all NM masses.
- Mass location plot (time=0 and at specified intervals)

Figure 2-23 illustrates a portion of this output for the sample case, for one typical cut in time. It should be noted that all this output is in inch, pound, second and radian units except XACCEL, YACCEL and ZACCEL. These are in g's. A more detailed description of the specific items printed out at each time follows.

2.3.3.2.1 Mass and Node Point Data. - X, Y and Z are the ground coordinates of mass I or node point I, M. The data for each node point are printed below the data for the mass to which they are attached. XDOT, YDOT and ZDOT are the ground axes components of the translational velocity of mass I or node point I, M. U, V and W are the corresponding components in mass fixed axes. UDOT, VDOT and WDOT (not printed for the node points) are the time derivatives of U, V and W. Note that these are not the translational acceleration components, but are used in Euler's equations of motion. XACCEL, YACCEL and ZACCEL are the body-fixed-axes components of the translational accelerations of mass I or node point I, M, in g units. XACFIL, YACFIL and ZACFIL are the same accelerations after passing through a first order filter with an input cutoff frequency. All the above quantities are positive forward, right and down.

PHI, THETA and PSI are the Euler angles defining the orientations of mass I with respect to the ground. These are positive right-wing-down, nose-up and nose-right, respectively. PHIDOT, THETADOT and PSIDOT are the time derivatives of the same angles. P, Q and R are the body axes components of

LT. SAMPLE DATA
 21 MASS/28 BEAM TEST CASE ONLY-NOT VALID AIRPLANE MODEL
 TIME = 0.050000 NUMBER OF INTEGRATION INTERVALS = 200
 MASS DISPLACEMENTS, VELOCITIES, AND ACCELERATIONS

	X			Y			Z			PHI			THETA			PSI		
	XDOT	UDOT	XACCEL	YDOT	V	YACCEL	ZDOT	W	ZACCEL	PHIDOT	P	XACFIL	THETADOT	Q	YACFIL	PSIDOT	R	ZACFIL
MASS 1	8.00733D 02	0.0	0.0	0.0	0.0	0.0	-1.47442D 02	0.0	0.0	0.0	0.0	0.0	1.99344D-02	0.0	0.0	0.0	0.0	0.0
	3.12727D 03	0.0	0.0	0.0	0.0	0.0	2.42624D 02	0.0	0.0	0.0	0.0	0.0	4.22122D-02	0.0	0.0	0.0	0.0	0.0
	3.12181D 03	0.0	0.0	0.0	0.0	0.0	3.04912D 02	0.0	0.0	0.0	0.0	0.0	4.22122D-02	0.0	0.0	0.0	0.0	0.0
	-8.02949D 02	0.0	0.0	0.0	0.0	0.0	3.0496D 02	0.0	0.0	0.0	0.0	0.0	-2.25872D 00	0.0	0.0	0.0	0.0	0.0
	-2.04683D 00	0.0	0.0	0.0	0.0	0.0	4.47455D-01	0.0	0.0	-2.09191D 00	0.0	0.0	0.0	0.0	0.0	5.90159D-01	0.0	0.0
MASS 2	6.99778D 02	0.0	0.0	0.0	0.0	0.0	-1.44129D 02	0.0	0.0	0.0	0.0	0.0	1.99257D-02	0.0	0.0	0.0	0.0	0.0
	3.12748D 03	0.0	0.0	0.0	0.0	0.0	2.47309D 02	0.0	0.0	0.0	0.0	0.0	5.09840D-02	0.0	0.0	0.0	0.0	0.0
	3.12193D 03	0.0	0.0	0.0	0.0	0.0	3.09573D 02	0.0	0.0	0.0	0.0	0.0	5.09840D-02	0.0	0.0	0.0	0.0	0.0
	-7.89332D 02	0.0	0.0	0.0	0.0	0.0	1.16746D 02	0.0	0.0	0.0	0.0	0.0	-1.99716D 00	0.0	0.0	0.0	0.0	0.0
	-2.00401D 00	0.0	0.0	0.0	0.0	0.0	-1.09904D-01	0.0	0.0	-2.06380D 00	0.0	0.0	0.0	0.0	0.0	-3.36351D-01	0.0	0.0
NODE 1	7.22192D 02	0.0	0.0	0.0	0.0	0.0	-7.33622D 01	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	3.13109D 03	0.0	0.0	0.0	0.0	0.0	2.66166D 02	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	3.12556D 03	0.0	0.0	0.0	0.0	0.0	3.08503D 02	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	-2.37254D 00	0.0	0.0	0.0	0.0	0.0	-1.73019D-03	0.0	0.0	-2.59084D 00	0.0	0.0	0.0	0.0	0.0	-1.81651D-01	0.0	0.0
MASS 3	5.40001D 02	0.0	0.0	0.0	0.0	0.0	-1.30965D 02	0.0	0.0	0.0	0.0	0.0	1.95106D-02	0.0	0.0	0.0	0.0	0.0
	3.12910D 03	0.0	0.0	0.0	0.0	0.0	2.57322D 02	0.0	0.0	0.0	0.0	0.0	6.14072D-02	0.0	0.0	0.0	0.0	0.0
	3.12348D 03	0.0	0.0	0.0	0.0	0.0	3.18320D 02	0.0	0.0	0.0	0.0	0.0	6.14072D-02	0.0	0.0	0.0	0.0	0.0
	-6.44915D 02	0.0	0.0	0.0	0.0	0.0	-2.40675D 02	0.0	0.0	0.0	0.0	0.0	-3.72638D 00	0.0	0.0	0.0	0.0	0.0
	-1.62012D 00	0.0	0.0	0.0	0.0	0.0	-1.12041D 00	0.0	0.0	-1.70710D 00	0.0	0.0	0.0	0.0	0.0	-9.77880D-01	0.0	0.0
MASS 4	3.80066D 02	0.0	0.0	0.0	0.0	0.0	-1.25204D 02	0.0	0.0	0.0	0.0	0.0	1.87936D-02	0.0	0.0	0.0	0.0	0.0
	3.13064D 03	0.0	0.0	0.0	0.0	0.0	2.61274D 02	0.0	0.0	0.0	0.0	0.0	-1.53279D-02	0.0	0.0	0.0	0.0	0.0
	3.12517D 03	0.0	0.0	0.0	0.0	0.0	3.20060D 02	0.0	0.0	0.0	0.0	0.0	-1.53279D-02	0.0	0.0	0.0	0.0	0.0
	-3.67004D 02	0.0	0.0	0.0	0.0	0.0	-1.34866D 03	0.0	0.0	0.0	0.0	0.0	-4.68099D 00	0.0	0.0	0.0	0.0	0.0
	-9.63496D-01	0.0	0.0	0.0	0.0	0.0	-3.36983D 00	0.0	0.0	-1.00582D 00	0.0	0.0	0.0	0.0	0.0	-2.20052D 00	0.0	0.0
MASS 5	1.80194D 02	0.0	0.0	0.0	0.0	0.0	-1.15644D 02	0.0	0.0	0.0	0.0	0.0	1.90969D-02	0.0	0.0	0.0	0.0	0.0
	3.13157D 03	0.0	0.0	0.0	0.0	0.0	2.54926D 02	0.0	0.0	0.0	0.0	0.0	-2.63228D-02	0.0	0.0	0.0	0.0	0.0
	3.12613D 03	0.0	0.0	0.0	0.0	0.0	3.14679D 02	0.0	0.0	0.0	0.0	0.0	-2.63228D-02	0.0	0.0	0.0	0.0	0.0
	-1.21743D 02	0.0	0.0	0.0	0.0	0.0	-1.88046D 03	0.0	0.0	0.0	0.0	0.0	6.69759D-01	0.0	0.0	0.0	0.0	0.0
	-3.36854D-01	0.0	0.0	0.0	0.0	0.0	-4.65948D 00	0.0	0.0	-4.37243D-01	0.0	0.0	0.0	0.0	0.0	-3.73706D 00	0.0	0.0
NODE 1	2.25452D 02	0.0	0.0	-4.80000D 01	0.0	0.0	-9.73046D 01	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	3.13108D 03	0.0	0.0	0.0	0.0	0.0	2.56118D 02	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	3.12562D 03	0.0	0.0	0.0	0.0	0.0	3.15861D 02	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	-3.03620D-01	0.0	0.0	0.0	0.0	0.0	-4.73642D 00	0.0	0.0	-4.46573D-01	0.0	0.0	0.0	0.0	0.0	-3.71546D 00	0.0	0.0
MASS 6	3.99989D 01	0.0	0.0	0.0	0.0	0.0	-1.24717D 02	0.0	0.0	0.0	0.0	0.0	2.50095D-02	0.0	0.0	0.0	0.0	0.0
	3.13100D 03	0.0	0.0	0.0	0.0	0.0	2.60638D 02	0.0	0.0	0.0	0.0	0.0	9.10641D-02	0.0	0.0	0.0	0.0	0.0
	3.12351D 03	0.0	0.0	0.0	0.0	0.0	3.38833D 02	0.0	0.0	0.0	0.0	0.0	9.10641D-02	0.0	0.0	0.0	0.0	0.0
	-2.97958D 02	0.0	0.0	0.0	0.0	0.0	-1.18411D 03	0.0	0.0	0.0	0.0	0.0	3.48013D 00	0.0	0.0	0.0	0.0	0.0
	-6.91971D-01	0.0	0.0	0.0	0.0	0.0	-3.80452D 00	0.0	0.0	-8.22834D-01	0.0	0.0	0.0	0.0	0.0	-3.03332D 00	0.0	0.0

FIGURE 2-23. KRASH85 TIME HISTORY OUTPUT (SHEET 1 OF 11)

LT. SAMPLE DATA

21 MASS/28 BEAM TEST CASE ONLY-NOT VALID AIRPLANE MODEL

TIME = 0.050000 NUMBER OF INTEGRATION INTERVALS = 200

MASS DISPLACEMENTS, VELOCITIES, AND ACCELERATIONS

	X			Y			Z			PHI			THETA			PSI		
	XDOT	U	XACCEL	YDOT	V	YACCEL	ZDOT	W	ZACCEL	PHIDOT	P	PHIFIL	THETADOT	Q	THETAFIL	PSIDOT	R	PSIFIL
MASS 7	-3.983940 01	0.0	0.0	-1.181390 02	0.0	0.0	-1.181390 02	0.0	0.0	0.0	0.0	0.0	2.688140-02	0.0	0.0	0.0	0.0	0.0
	3.131280 03	0.0	0.0	2.687940 02	0.0	0.0	2.687940 02	0.0	0.0	0.0	0.0	0.0	1.098350-01	0.0	0.0	0.0	0.0	0.0
	3.122920 03	0.0	0.0	3.528600 02	0.0	0.0	3.528600 02	0.0	0.0	0.0	0.0	0.0	1.098350-01	0.0	0.0	0.0	0.0	0.0
	-3.827260 02	0.0	0.0	-9.354050 02	0.0	0.0	-9.354050 02	0.0	0.0	0.0	0.0	0.0	9.953400-01	0.0	0.0	0.0	0.0	0.0
	-8.911120-01	0.0	0.0	-3.311950 00	0.0	0.0	-3.311950 00	0.0	0.0	-1.053500 00	0.0	-1.053500 00	0.0	0.0	0.0	-2.874590 00	0.0	-2.874590 00
MASS 8	-2.002150 02	0.0	0.0	-1.308110 02	0.0	0.0	-1.308110 02	0.0	0.0	0.0	0.0	0.0	2.918380-02	0.0	0.0	0.0	0.0	0.0
	3.129170 03	0.0	0.0	2.895010 02	0.0	0.0	2.895010 02	0.0	0.0	0.0	0.0	0.0	1.491320-01	0.0	0.0	0.0	0.0	0.0
	3.119390 03	0.0	0.0	3.806860 02	0.0	0.0	3.806860 02	0.0	0.0	0.0	0.0	0.0	1.491320-01	0.0	0.0	0.0	0.0	0.0
	-4.005770 02	0.0	0.0	-1.679210 03	0.0	0.0	-1.679210 03	0.0	0.0	0.0	0.0	0.0	-1.057380 01	0.0	0.0	0.0	0.0	0.0
	-8.906860-01	0.0	0.0	-5.555470 00	0.0	0.0	-5.555470 00	0.0	0.0	-1.139650 00	0.0	-1.139650 00	0.0	0.0	0.0	-5.737590 00	0.0	-5.737590 00
MASS 9	-3.610240 02	0.0	0.0	-1.609320 02	0.0	0.0	-1.609320 02	0.0	0.0	0.0	0.0	0.0	2.999740-02	0.0	0.0	0.0	0.0	0.0
	3.122680 03	0.0	0.0	3.234030 02	0.0	0.0	3.234030 02	0.0	0.0	0.0	0.0	0.0	2.683250-01	0.0	0.0	0.0	0.0	0.0
	3.111570 03	0.0	0.0	4.169160 02	0.0	0.0	4.169160 02	0.0	0.0	0.0	0.0	0.0	2.683250-01	0.0	0.0	0.0	0.0	0.0
	-4.445610 02	0.0	0.0	-2.127990 03	0.0	0.0	-2.127990 03	0.0	0.0	0.0	0.0	0.0	5.159320 00	0.0	0.0	0.0	0.0	0.0
	-8.618950-01	0.0	0.0	-7.675910 00	0.0	0.0	-7.675910 00	0.0	0.0	-1.338880 00	0.0	-1.338880 00	0.0	0.0	0.0	-7.123210 00	0.0	-7.123210 00
MASS 10	-5.722700 02	0.0	0.0	-1.969340 02	0.0	0.0	-1.969340 02	0.0	0.0	0.0	0.0	0.0	2.963800-02	0.0	0.0	0.0	0.0	0.0
	3.110500 03	0.0	0.0	3.861750 02	0.0	0.0	3.861750 02	0.0	0.0	0.0	0.0	0.0	3.154010-01	0.0	0.0	0.0	0.0	0.0
	3.097690 03	0.0	0.0	4.781810 02	0.0	0.0	4.781810 02	0.0	0.0	0.0	0.0	0.0	3.154010-01	0.0	0.0	0.0	0.0	0.0
	-1.468310 03	0.0	0.0	1.382340 03	0.0	0.0	1.382340 03	0.0	0.0	0.0	0.0	0.0	2.622170 01	0.0	0.0	0.0	0.0	0.0
	-3.415790 00	0.0	0.0	1.050080 00	0.0	0.0	1.050080 00	0.0	0.0	-3.833480 00	0.0	-3.833480 00	0.0	0.0	0.0	1.426810 00	0.0	1.426810 00
MASS 11	1.990350 02	-1.183500 02	-1.183500 02	-1.183500 02	-1.183500 02	-1.183500 02	-1.183500 02	-1.183500 02	-1.183500 02	7.374770-03	7.374770-03	7.374770-03	-7.028300-04	-7.028300-04	-7.028300-04	5.495340-04	5.495340-04	5.495340-04
	3.130390 03	-2.050980-01	-2.050980-01	-2.050980-01	-2.050980-01	-2.050980-01	-2.050980-01	-2.050980-01	-2.050980-01	6.021920-02	6.021920-02	6.021920-02	-4.808040-01	-4.808040-01	-4.808040-01	1.218200-02	1.218200-02	1.218200-02
	3.130560 03	-1.605820-01	-1.605820-01	-1.605820-01	-1.605820-01	-1.605820-01	-1.605820-01	-1.605820-01	-1.605820-01	6.022740-02	6.022740-02	6.022740-02	-4.807010-01	-4.807010-01	-4.807010-01	1.572750-02	1.572750-02	1.572750-02
	1.228280 02	-9.364570 01	-9.364570 01	-9.364570 01	-9.364570 01	-9.364570 01	-9.364570 01	-9.364570 01	-9.364570 01	1.357490 00	1.357490 00	1.357490 00	2.730200 00	2.730200 00	2.730200 00	8.045280-01	8.045280-01	8.045280-01
	2.020230-02	-1.523900-01	-1.523900-01	-1.523900-01	-1.523900-01	-1.523900-01	-1.523900-01	-1.523900-01	-1.523900-01	-1.458410-01	-1.458410-01	-1.458410-01	-3.044300-01	-3.044300-01	-3.044300-01	-5.591280 00	-5.591280 00	-5.591280 00
NODE 1	2.264340 02	-1.183500 02	-1.183500 02	-1.183500 02	-1.183500 02	-1.183500 02	-1.183500 02	-1.183500 02	-1.183500 02	-1.708650-01	-1.708650-01	-1.708650-01	-2.565280-01	-2.565280-01	-2.565280-01	-5.469540 00	-5.469540 00	-5.469540 00
	3.129420 03	7.700120-03	7.700120-03	7.700120-03	7.700120-03	7.700120-03	7.700120-03	7.700120-03	7.700120-03	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	3.129600 03	1.498920-01	1.498920-01	1.498920-01	1.498920-01	1.498920-01	1.498920-01	1.498920-01	1.498920-01	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	1.793480-02	-1.044090-01	-1.044090-01	-1.044090-01	-1.044090-01	-1.044090-01	-1.044090-01	-1.044090-01	-1.044090-01	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
NODE 2	1.133370 02	-1.317590 02	-1.317590 02	-1.317590 02	-1.317590 02	-1.317590 02	-1.317590 02	-1.317590 02	-1.317590 02	-9.497880-02	-9.497880-02	-9.497880-02	-6.767670-01	-6.767670-01	-6.767670-01	-6.179750 00	-6.179750 00	-6.179750 00
	3.126500 03	-1.763240 00	-1.763240 00	-1.763240 00	-1.763240 00	-1.763240 00	-1.763240 00	-1.763240 00	-1.763240 00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	3.126640 03	-2.026350 00	-2.026350 00	-2.026350 00	-2.026350 00	-2.026350 00	-2.026350 00	-2.026350 00	-2.026350 00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	1.611230-01	-3.548610-01	-3.548610-01	-3.548610-01	-3.548610-01	-3.548610-01	-3.548610-01	-3.548610-01	-3.548610-01	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
NODE 3	1.133370 02	-1.317590 02	-1.317590 02	-1.317590 02	-1.317590 02	-1.317590 02	-1.317590 02	-1.317590 02	-1.317590 02	-9.497880-02	-9.497880-02	-9.497880-02	-6.767670-01	-6.767670-01	-6.767670-01	-6.179750 00	-6.179750 00	-6.179750 00
	3.126500 03	-1.763240 00	-1.763240 00	-1.763240 00	-1.763240 00	-1.763240 00	-1.763240 00	-1.763240 00	-1.763240 00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	3.126640 03	-2.026350 00	-2.026350 00	-2.026350 00	-2.026350 00	-2.026350 00	-2.026350 00	-2.026350 00	-2.026350 00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	1.611230-01	-3.548610-01	-3.548610-01	-3.548610-01	-3.548610-01	-3.548610-01	-3.548610-01	-3.548610-01	-3.548610-01	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
MASS 12	1.480750 02	-2.717770 02	-2.717770 02	-2.717770 02	-2.717770 02	-2.717770 02	-2.717770 02	-2.717770 02	-2.717770 02	6.521040-03	6.521040-03	6.521040-03	5.808480-03	5.808480-03	5.808480-03	6.553300-04	6.553300-04	6.553300-04
	3.133900 03	-5.1139860-01	-5.1139860-01	-5.1139860-01	-5.1139860-01	-5.1139860-01	-5.1139860-01	-5.1139860-01	-5.1139860-01	-3.422350-01	-3.422350-01	-3.422350-01	-3.905980-01	-3.905980-01	-3.905980-01	-5.082670-02	-5.082670-02	-5.082670-02

FIGURE 2-23. KRASH85 TIME HISTORY OUTPUT (SHEET 2 OF 11)

3.13241D 03	-8.37753D-01	2.65297D 02	-3.41940D-01	-3.90922D-01	-4.82777D-02
-1.81794D 02	3.33001D 01	-3.05037D 03	-5.03209D 00	5.78854D 00	-2.78703D 00
-7.39754D-01	-7.04915D-02	-4.72943D 00	-8.31290D-01	-1.67644D-01	-4.40509D 00
1.88624D 02	-3.21572D 02	-1.17403D 02			
3.13032D 03	-1.48885D 00	2.79963D 02			
3.12864D 03	-1.59600D 00	2.98158D 02			
-1.08020D 00	-2.87691D-01	-4.69070D 00	-1.39422D 00	-4.53750D-01	-2.67885D 00

NODE 1
 2-168

FIGURE 2-23. KRASH85 TIME HISTORY OUTPUT (SHEET 3 OF 11)

LT SAMPLE DATA
 21 MASS/28 BEAM TEST CASE ONLY-NOT VALID AIRPLANE MODEL
 TIME = 0.050000 NUMBER OF INTEGRATION INTERVALS = 200
 MASS DISPLACEMENTS, VELOCITIES, AND ACCELERATIONS

	X			Y			Z			PHI			THETA			PSI		
	XDOT	UDOT	XACCEL	YDOT	VDOT	YACCEL	ZDOT	WDOT	ZACCEL	PHIDOT	P	XACFIL	THETADOT	Q	DOT	PSIDOT	R	ZACFIL
MASS 13	5.686090 01	-4.305160 02	-1.381010 02	-4.305160 02	-1.381010 02	-1.381010 02	-1.381010 02	-1.381010 02	-1.381010 02	1.468300-02			9.565790-03			9.944850-04		
	3.132230 03	-2.661830 02	2.784350 02	-2.661830 02	2.784350 02	2.784350 02	2.784350 02	2.784350 02	2.784350 02	-3.305980-01			-1.125900-01			-3.292120-02		
	3.129520 03	-1.248420 00	3.084370 02	-1.248420 00	3.084370 02	3.084370 02	3.084370 02	3.084370 02	3.084370 02	-3.302830-01			-1.130620-01			-3.126300-02		
	-7.198730 02	1.413290 02	-2.529290 03	1.413290 02	-2.529290 03	-2.529290 03	-2.529290 03	-2.529290 03	-2.529290 03	-4.442410 00			-1.323560 01			-2.119510 00		
	-1.955400 00	3.765860-01	-5.634840 00	3.765860-01	-5.634840 00	-5.634840 00	-5.634840 00	-5.634840 00	-5.634840 00	-1.705040 00			1.963090-01			-5.687150 00		
MASS 14	-4.538840 01	-5.829340 02	-1.638260 02	-5.829340 02	-1.638260 02	-1.638260 02	-1.638260 02	-1.638260 02	-1.638260 02	2.528660-02			1.441510-02			4.137140-03		
	3.124140 03	-4.208510 00	3.259670 02	-4.208510 00	3.259670 02	3.259670 02	3.259670 02	3.259670 02	3.259670 02	-1.545950-01			4.143040-02			-7.596350-02		
	3.119080 03	-7.748540 00	3.712800 02	-7.748540 00	3.712800 02	3.712800 02	3.712800 02	3.712800 02	3.712800 02	-1.535500-01			3.950470-02			-7.697900-02		
	-9.178190 02	-2.012040 01	2.346390 02	-2.012040 01	2.346390 02	2.346390 02	2.346390 02	2.346390 02	2.346390 02	-1.529560 01			-4.720640 00			-1.262720 00		
	-2.341320 00	-5.265080-01	2.917370-01	-5.265080-01	2.917370-01	2.917370-01	2.917370-01	2.917370-01	2.917370-01	-1.999360 00			-6.861410-01			4.864550-01		
NODE 1	6.117260 00	-5.514330 02	-1.407720 02	-5.514330 02	-1.407720 02	-1.407720 02	-1.407720 02	-1.407720 02	-1.407720 02	-2.045520 00			-9.330420-02			-2.380630-01		
	3.127410 03	-4.438690 00	3.189910 02	-4.438690 00	3.189910 02	3.189910 02	3.189910 02	3.189910 02	3.189910 02									
	3.122440 03	-8.167320 00	3.643600 02	-8.167320 00	3.643600 02	3.643600 02	3.643600 02	3.643600 02	3.643600 02									
	-2.519070 00	2.135450-01	-3.443390-01	2.135450-01	-3.443390-01	-3.443390-01	-3.443390-01	-3.443390-01	-3.443390-01									
MASS 15	-1.114810 02	-7.401760 02	-1.777940 02	-7.401760 02	-1.777940 02	-1.777940 02	-1.777940 02	-1.777940 02	-1.777940 02	1.775340-02			1.343720-02			4.675950-03		
	3.116510 03	-6.439790-01	3.255780 02	-6.439790-01	3.255780 02	3.255780 02	3.255780 02	3.255780 02	3.255780 02	7.866320-02			7.828820-02			-2.526880-02		
	3.111810 03	-8.691460 00	3.676360 02	-8.691460 00	3.676360 02	3.676360 02	3.676360 02	3.676360 02	3.676360 02	7.900280-02			7.782740-02			-2.665240-02		
	-1.055770 03	1.234060 02	5.219040 02	1.234060 02	5.219040 02	5.219040 02	5.219040 02	5.219040 02	5.219040 02	3.271230 00			-4.759400 00			-1.461560-01		
	-2.661630 00	-6.098120-01	7.228840-01	-6.098120-01	7.228840-01	7.228840-01	7.228840-01	7.228840-01	7.228840-01	-2.388960 00			-5.680970-01			3.611980-01		
NODE 1	-1.469600 02	-7.402260 02	-1.835180 02	-7.402260 02	-1.835180 02	-1.835180 02	-1.835180 02	-1.835180 02	-1.835180 02									
	3.116060 03	7.381900-01	3.283650 02	7.381900-01	3.283650 02	3.283650 02	3.283650 02	3.283650 02	3.283650 02									
	3.111330 03	-7.258060 00	3.703910 02	-7.258060 00	3.703910 02	3.703910 02	3.703910 02	3.703910 02	3.703910 02	-2.331630 00			-4.519470-01			3.908690-02		
	-2.584500 00	-5.443810-01	2.868600-01	-5.443810-01	2.868600-01	2.868600-01	2.868600-01	2.868600-01	2.868600-01									
NODE 2	-1.114810 02	-7.401760 02	-1.777940 02	-7.401760 02	-1.777940 02	-1.777940 02	-1.777940 02	-1.777940 02	-1.777940 02									
	3.116510 03	-6.439790-01	3.255780 02	-6.439790-01	3.255780 02	3.255780 02	3.255780 02	3.255780 02	3.255780 02									
	3.111810 03	-8.691460 00	3.676360 02	-8.691460 00	3.676360 02	3.676360 02	3.676360 02	3.676360 02	3.676360 02	-2.388960 00			-5.680970-01			3.611980-01		
	-2.661630 00	-6.098120-01	7.228840-01	-6.098120-01	7.228840-01	7.228840-01	7.228840-01	7.228840-01	7.228840-01									
MASS 16	2.818450 02	-3.218720 02	-8.455870 01	-3.218720 02	-8.455870 01	-8.455870 01	-8.455870 01	-8.455870 01	-8.455870 01	-7.571060-02			4.691760-02			5.406200-02		
	3.134590 03	1.432950 00	2.967760 02	1.432950 00	2.967760 02	2.967760 02	2.967760 02	2.967760 02	2.967760 02	-8.003930-02			9.606240-02			-3.579530-02		
	3.112730 03	-2.009950 02	4.292790 02	-2.009950 02	4.292790 02	4.292790 02	4.292790 02	4.292790 02	4.292790 02	-7.836050-02			9.849170-02			-2.838740-02		
	-3.625800 02	2.187180 01	1.156560 03	2.187180 01	1.156560 03	1.156560 03	1.156560 03	1.156560 03	1.156560 03	-1.451650 01			-7.031210 00			-1.137560 00		
	-8.471640-01	-8.510870-02	2.242830 00	-8.510870-02	2.242830 00	2.242830 00	2.242830 00	2.242830 00	2.242830 00	-7.213900-01			-4.951400-02			2.460030 00		
NODE 1	2.647210 02	-3.215240 02	-8.455870 01	-3.215240 02	-8.455870 01	-8.455870 01	-8.455870 01	-8.455870 01	-8.455870 01									
	3.131530 03	-8.735920-01	2.983150 02	-8.735920-01	2.983150 02	2.983150 02	2.983150 02	2.983150 02	2.983150 02									
	3.104470 02	-2.032310 02	4.305010 02	-2.032310 02	4.305010 02	4.305010 02	4.305010 02	4.305010 02	4.305010 02	-7.539610-01			-5.362720-01			2.420820 00		
	-2.135550-01	-1.323290 00	1.816590 00	-1.323290 00	1.816590 00	1.816590 00	1.816590 00	1.816590 00	1.816590 00									
NODE 2	2.818450 02	-3.218720 02	-8.455870 01	-3.218720 02	-8.455870 01	-8.455870 01	-8.455870 01	-8.455870 01	-8.455870 01									
	3.134590 03	1.432950 00	2.967760 02	1.432950 00	2.967760 02	2.967760 02	2.967760 02	2.967760 02	2.967760 02									
	3.112730 03	-2.009950 02	4.292790 02	-2.009950 02	4.292790 02	4.292790 02	4.292790 02	4.292790 02	4.292790 02									
	-3.625800 02	2.187180 01	1.156560 03	2.187180 01	1.156560 03	1.156560 03	1.156560 03	1.156560 03	1.156560 03									
	-8.471640-01	-8.510870-02	2.242830 00	-8.510870-02	2.242830 00	2.242830 00	2.242830 00	2.242830 00	2.242830 00									

FIGURE 2-23. KRASH85 TIME HISTORY OUTPUT (SHEET 4 OF 11)

-8.47164D-01 -8.51087D-02 2.24283D 00 -7.21390D-01 -4.95140D-02 2.46003D 00

FIGURE 2-23. KRASH85 TIME HISTORY OUTPUT (SHEET 5 OF 11)

LT. SAMPLE DATA
 21 MASS/20 BEAM TEST CASE ONLY-NOT VALID AIRPLANE MODEL
 TIME = 0.050000 NUMBER OF INTEGRATION INTERVALS = 200
 MASS DISPLACEMENTS, VELOCITIES, AND ACCELERATIONS

	X	Y	Z	PHI	THETA	PSI
	XDOT	YDOT	ZDOT	PHIDOT	THETADOT	PSIDOT
	U	V	W	P	Q	R
	UACCEL	VACCEL	ZACCEL	PACCEL	QACCEL	RACCEL
MASS 17	9.826580 01	-5.516590 02	-1.096500 02	-6.299560-02	4.749380-02	6.006260-02
	3.135610 03	-1.954710 00	3.096500 02	-1.009230-01	2.191820-01	5.318160-02
	3.111610 03	-2.186200 02	4.450130 02	-1.034480-01	2.154030-01	6.681660-02
	-9.808390 02	-2.505300 02	5.691620 02	4.477610-01	4.584970 00	1.197720 00
	-2.254860 00	8.626340-03	-2.032970-01	-1.452980 00	-9.172730-02	1.889570-01
NODE 1	8.221500 01	-5.510030 02	-1.418120 02			
	3.128730 03	-6.544770 00	3.129900 02			
	3.104320 03	-2.229690 02	4.677420 02			
	-2.652640 00	1.449460-03	-2.229480-02	-1.905140 00	-1.792610-01	3.841710-01
MASS 18	1.112410 02	-1.324280 02	-1.481760 01	8.690360-03	-3.817860-02	1.213420-04
	3.130980 03	1.516570 01	-1.098110 01	-2.867310-01	2.428990-01	9.428680-03
	3.128280 03	1.365130 01	-1.306050 02	-2.863710-01	2.429720-01	7.310590-03
	1.090360 04	4.177840 02	1.652210 04	-9.440670 00	1.850900 02	2.590940 00
	2.816520 01	1.044690 00	4.082420 01	2.818360 01	2.515830 00	2.636410 01
MASS 19	7.223520 02	0.0	-1.212460 01	0.0	-7.803860-03	0.0
	3.038630 03	0.0	1.480770 02	0.0	-2.381050 00	0.0
	3.039690 03	0.0	1.243600 02	0.0	-2.381050 00	0.0
	-2.185240 03	0.0	-9.446120 03	0.0	-3.950430 01	0.0
	-6.428370 00	0.0	-5.721390 00	-1.101720 01	0.0	-6.890770 00
MASS 20	6.994570 02	0.0	-1.640510 02	0.0	1.827460-02	0.0
	3.134620 03	0.0	2.489230 02	0.0	7.007600-02	0.0
	3.129550 03	0.0	3.061620 02	0.0	7.007600-02	0.0
	-2.318450 02	0.0	2.420720 02	0.0	-5.213080 00	0.0
	-5.450520-01	0.0	5.897840-02	-4.190590-01	0.0	1.542810-01
MASS 21	6.994360 02	0.0	-1.639540 02	0.0	2.018070-02	0.0
	3.135040 03	0.0	2.512190 02	0.0	7.598700-02	0.0
	3.129330 03	0.0	3.144310 02	0.0	7.598700-02	0.0
	-1.919880 02	0.0	9.882320 01	0.0	-4.237770 00	0.0
	-4.354800-01	0.0	-3.600140-01	-3.300370-01	0.0	-2.727440-01

NO MASS IMPULSE DATA REQUESTED

BEAM FORCES

STRAIN FORCES

I	J	M	N	FX	FY	FZ	MX	MY	MZ
1	2	0	0	3.22040 03	0.0	-8.09770 02	0.0	-9.48460 04	1.30520 04
2	3	0	0	1.44790 04	0.0	2.45210 04	0.0	-2.90570 04	3.96020 06
3	4	0	0	3.77520 04	0.0	-5.47810 03	0.0	-4.23440 06	3.40800 06
									0.0

FIGURE 2-23. KRASH85 TIME HISTORY OUTPUT (SHEET 6 OF 11)

LOADS ARE THOSE ACTING ON THE MASS, IN MASS AXES, +FND,RT,ON
FOR EACH BEAM, FIRST LINE IS MASS I, SECOND LINE IS MASS J

I	J	M	N	FX	FY	FZ	MX	MY	NZ
1	2	0	0	-3.21260 03	0.0	-7.80470 02	0.0	-9.03490 04	0.0
				3.21260 03	0.0	7.80440 02	0.0	7.34680 03	0.0
2	3	0	0	-1.24340 04	0.0	2.59040 04	0.0	2.70710 04	0.0
				1.24240 04	0.0	-2.59090 04	0.0	3.99370 06	0.0
3	4	0	0	-3.69420 04	0.0	-4.70730 03	0.0	-4.35500 06	0.0
				3.69450 04	0.0	4.68090 03	0.0	3.50450 06	0.0
4	5	0	0	-4.93170 04	0.0	-5.71910 04	0.0	-3.81680 06	0.0
				4.93000 04	0.0	5.72060 04	0.0	-7.90780 06	0.0
5	6	0	0	1.63620 05	0.0	1.86100 05	0.0	6.10100 07	0.0
				-1.62510 05	0.0	-1.87070 05	0.0	-3.68740 07	0.0
6	7	0	0	1.32940 05	0.0	1.60810 05	0.0	3.85310 07	0.0
				-1.32640 05	0.0	-1.61060 05	0.0	-2.50590 07	0.0
7	8	0	0	1.24700 05	0.0	1.23750 05	0.0	2.51990 07	0.0
				-1.24410 05	0.0	-1.24040 05	0.0	-7.51700 06	0.0
8	9	0	0	1.15850 05	0.0	5.96750 04	0.0	5.61370 06	0.0
				-1.15800 05	0.0	-5.97690 04	0.0	-1.05340 05	0.0
9	10	0	0	2.09040 04	0.0	1.71410 04	0.0	-1.15030 05	0.0
				-2.09100 04	0.0	-1.71340 04	0.0	2.83140 06	0.0
5	11	0	1	-1.09910 05	-7.91500 03	-1.79250 05	-2.19630 07	-2.65090 07	-1.81470 07
				1.13450 05	9.15810 03	1.76970 05	-5.42470 05	2.86560 07	4.78940 06
11	12	1	0	-1.08460 04	-7.27460 03	2.98910 04	-3.14650 06	4.51600 06	-3.43090 06
				1.10410 04	7.29940 03	-2.98140 04	-1.56090 06	-2.83570 06	2.12510 06
12	13	0	0	-1.04110 04	1.11980 04	2.27690 03	1.89290 06	1.01930 06	-2.67230 06
				1.04150 04	-1.12190 04	-2.14630 03	-2.06130 06	-6.31440 05	-5.02600 03
13	14	0	0	-2.07020 04	1.31320 04	-1.15340 04	2.02920 06	-6.60700 04	-2.26430 05
				2.06050 04	-1.30720 04	1.17740 04	7.24480 04	-6.51080 05	-4.26940 06
14	15	0	1	3.78260 03	-7.32040 04	-3.94660 03	-7.85540 05	-2.83570 05	4.48120 06
				-3.73760 03	7.31760 04	4.50210 03	6.05260 05	-2.82160 04	9.83940 05
12	16	1	1	4.05050 03	-3.11350 02	-7.15700 03	4.13070 05	1.29460 06	1.86620 05
				-4.32140 03	-5.15900 01	7.00350 03	-5.30180 04	-1.83920 05	-4.34350 04
14	17	1	1	1.15420 04	7.95130 02	5.53750 03	1.38490 05	-2.71840 05	-2.57730 05
				-1.13700 04	3.69370 02	-5.92390 03	1.71380 03	1.19590 05	1.17440 04
11	18	2	0	-4.81290 04	-1.61320 03	-2.47540 05	3.48990 06	-2.69180 07	-5.03980 05
				5.73700 04	1.94220 03	2.45570 05	-1.49020 04	5.73590 05	2.34820 03
11	18	3	0	-5.42820 04	-1.81540 03	-1.38820 03	2.18110 05	-5.87580 06	-5.68470 05
				5.42950 04	1.82280 03	-6.49040 02	-1.49020 04	5.73570 05	2.34820 03
2	19	1	0	-9.28820 03	0.0	-3.70610 04	0.0	-6.29240 05	0.0

FIGURE 2-23. KRASH85 TIME HISTORY OUTPUT (SHEET 8 OF 11)

6	12	0	0	1.0212D 04	0.0	3.6789D 04	0.0	1.3176D 05	0.0
9	14	0	0	1.2151D 04	-1.4974D 04	-4.8560D 03	1.9138D 06	-6.1939D 05	1.7182D 06
12	0	0	0	-1.2046D 04	1.5015D 04	4.9907D 03	-4.0797D 05	1.2296D 06	-3.0638D 04
				4.5076D 04	-8.3152D 04	-3.1947D 03	1.9062D 06	2.1798D 05	3.0019D 04
				-4.4676D 04	8.3409D 04	1.7933D 03	5.0708D 05	1.0839D 06	-2.9935D 04
12	0	0	0	-2.2266D 01	-3.3976D 04	2.2143D 02	-3.5194D 05	-2.5788D 03	-4.3107D 05
THERE IS NO MASS AT J END OF THIS BEAM									
2	20	0	0	5.2522D 02	0.0	9.4172D 02	0.0	-5.3234D 03	0.0
				-5.2678D 02	0.0	-9.4085D 02	0.0	-5.2131D 03	0.0
2	21	0	0	0.0	0.0	0.0	0.0	0.0	0.0
				-4.1530D 02	0.0	-1.3598D 03	0.0	-4.2378D 03	0.0
15	16	0	0	0.0	0.0	0.0	0.0	0.0	0.0
				0.0	0.0	0.0	0.0	0.0	0.0
15	16	2	2	0.0	0.0	0.0	0.0	0.0	0.0
				0.0	0.0	0.0	0.0	0.0	0.0
15	0	0	0	0.0	0.0	-2.9991D 05	-7.3245D 03	-4.9326D 05	
THERE IS NO MASS AT J END OF THIS BEAM									
15	0	2	0	-3.4672D 02	-7.4144D 04	1.3118D 03	-2.9991D 05	-7.3245D 03	-4.9326D 05
THERE IS NO MASS AT J END OF THIS BEAM									

BEAM RELATIVE DEFLECTIONS AND ROTATIONS AND BEAM EULER ANGLES (INCHES AND DEGREES)

BEAM				DEFLECTIONS (J-I)				ROTATIONS (J-I)				ROTATIONS (J+I)				EULER ANGLES			
I	J	M	N	X	Y	Z	PHI	THETA	PSI	THETA	PSI	THETA	PSI	THETA	PSI	M	THETA	PSI	B
1	1	2	0	1.0165D-03	0.0	-5.5700D-04	0.0	5.0358D-04	0.0	-2.8429D-01	0.0	-2.8429D-01	0.0	-2.8429D-01	0.0	0	-1.9	180.0	0
2	3	0	0	6.4476D-03	0.0	-2.2363D-02	0.0	2.3795D-02	0.0	-2.5999D-01	0.0	-2.5999D-01	0.0	-2.5999D-01	0.0	0	-4.7	180.0	0
3	4	0	0	1.6781D-02	0.0	-5.9455D-02	0.0	4.1006D-02	0.0	-1.9519D-01	0.0	-1.9519D-01	0.0	-1.9519D-01	0.0	0	-2.1	180.0	0
4	5	0	0	1.6486D-02	0.0	2.0709D-03	0.0	-1.7385D-02	0.0	-1.7157D-01	0.0	-1.7157D-01	0.0	-1.7157D-01	0.0	0	-2.7	180.0	0
5	6	0	0	-4.2575D-02	0.0	4.4932D-01	0.0	-3.3865D-01	0.0	-5.2761D-01	0.0	-5.2761D-01	0.0	-5.2761D-01	0.0	0	3.7	180.0	0
6	7	0	0	-1.7412D-02	0.0	8.0283D-02	0.0	-1.0724D-01	0.0	-9.7350D-01	0.0	-9.7350D-01	0.0	-9.7350D-01	0.0	0	-4.7	180.0	0
7	8	0	0	-4.6039D-02	0.0	2.1871D-01	0.0	-1.3188D-01	0.0	-1.2126D 00	0.0	-1.2126D 00	0.0	-1.2126D 00	0.0	0	4.5	180.0	0
8	9	0	0	-5.5706D-02	0.0	8.8372D-02	0.0	-4.6500D-02	0.0	-1.3910D 00	0.0	-1.3910D 00	0.0	-1.3910D 00	0.0	0	10.6	180.0	0
9	10	0	0	-2.0843D-02	0.0	-2.7262D-02	0.0	2.0637D-02	0.0	-1.4169D 00	0.0	-1.4169D 00	0.0	-1.4169D 00	0.0	0	9.7	180.0	0
11	11	0	1	-1.2032D-02	-1.2215D-01	-1.6645D-01	1.2066D 00	-1.8286D-02	-9.4856D-02	5.0365D-02	-7.6441D-02	5.0365D-02	-7.6441D-02	5.0365D-02	-7.6441D-02	0	-5.8	-68.7	0
12	12	1	0	2.4887D-03	-4.5405D-02	4.3635D-01	-3.0851D-01	-2.1292D-01	-2.8345D-02	1.4841D 00	1.9016D-01	1.4841D 00	1.9016D-01	1.4841D 00	1.9016D-01	0	5.8	-117.1	0
13	13	0	0	-1.4743D-03	-5.6197D-02	-4.5999D-01	-4.1797D-01	2.9645D-01	-2.6862D-02	1.6095D 00	1.2497D-01	1.6095D 00	1.2497D-01	1.6095D 00	1.2497D-01	0	5.5	-119.9	0
14	14	0	1	1.0928D-03	9.6950D-02	-8.7936D-01	-5.8765D-01	3.4814D-01	9.7928D-02	2.2490D 00	1.6861D-01	2.2490D 00	1.6861D-01	2.2490D 00	1.6861D-01	0	8.0	-123.9	0
12	16	1	1	5.6013D-02	4.0334D-01	6.2125D-01	2.7516D-01	-3.3426D-01	6.3806D-02	2.2846D 00	3.8560D-01	2.2846D 00	3.8560D-01	2.2846D 00	3.8560D-01	0	6.0	-122.9	0
14	17	1	1	3.3986D-03	1.6671D-03	-2.9704D-01	2.4965D-01	3.8862D-01	3.1455D-02	-9.4644D-01	9.8933D-02	-9.4644D-01	9.8933D-02	-9.4644D-01	9.8933D-02	0	0.6	0.0	0
11	18	2	0	7.4061D 00	7.5502D-02	-2.1725D 00	-6.9119D-03	-2.9678D-02	1.5342D-01	5.8823D-01	5.8823D-01	5.8823D-01	5.8823D-01	5.8823D-01	5.8823D-01	0	0.8	0.3	0
11	18	3	0	-7.4061D 00	7.5502D-02	-2.1725D 00	-6.9119D-03	2.1480D 00	7.5196D-02	4.2266D 00	9.1959D-01	4.2266D 00	9.1959D-01	4.2266D 00	9.1959D-01	1	1.5	-179.5	0
2	19	1	0	-1.2537D 00	0.0	-1.0678D 00	0.0	1.5865D 00	0.0	1.3027D 00	0.0	1.3027D 00	0.0	1.3027D 00	0.0	1	1.5	-179.5	0
6	12	0	0	1.2749D-02	2.2501D-01	-2.2261D 00	1.1607D 00	-5.8914D-02	9.9165D-03	2.6086D-01	2.7485D-02	2.6086D-01	2.7485D-02	2.6086D-01	2.7485D-02	0	-0.9	-68.3	0
9	14	0	0	1.5262D-01	1.5855D 00	-9.9282D 00	1.4739D 00	8.4410D-01	2.2855D-01	1.5286D 00	2.3572D-01	1.5286D 00	2.3572D-01	1.5286D 00	2.3572D-01	0	0.3	-61.6	0
12	0	0	0	-4.5802D-02	-3.5662D-01	-3.5418D 00	0.0	7.4676D-01	-7.5189D-02	0.0	1.8917D-01	0.0	1.8917D-01	0.0	1.8917D-01	0	0.0	90.0	0
2	20	0	0	-7.5377D-02	0.0	7.5738D-02	0.0	-9.4619D-02	0.0	1.4585D-02	0.0	1.4585D-02	0.0	1.4585D-02	0.0	1	1.0	0.0	0
2	21	0	0	-1.7220D-01	0.0	5.3248D-02	0.0	1.4585D-02	0.0	2.9837D-01	0.0	2.9837D-01	0.0	2.9837D-01	0.0	1	1.0	0.0	0
15	16	0	0	7.4813D-02	-7.9765D-01	1.8515D 00	-3.2985D-01	2.5063D-01	-1.3959D-01	-1.5407D 00	2.0390D-01	-1.5407D 00	2.0390D-01	-1.5407D 00	2.0390D-01	0	-9.2	46.8	0

FIGURE 2-23. KRASH85 TIME HISTORY OUTPUT (SHEET 9 OF 11)

15 16 2 2 7.4813D-02 -7.9745D-01 1.8515D 00 -3.2985D-01 2.5043D-C1 -1.3958D-01 -1.5407D 00 2.0390D-01 0 -9.2 46.8
 15 0 0 -8.4888D-01 -6.9222D 00 -2.6120D 01 0.0 2.0219D 00 -5.3585D-01 0.0 0.0 0 0.0 90.0
 15 0 2 0 -8.4888D-01 -6.9222D 00 -2.6120D 01 0.0 2.0219D 00 -5.3585D-01 0.0 0.0 0 0.0 90.0

EXTERNAL SPRINGS

MASS SPRING		GROUND DEFLECTION		SPRING COMPRESSION		GROUND CONTACT POINT LOADS IN GROUND OR SLOPE AXES		GROUND CONTACT POINT LOADS IN MASS AXES			
I	K	M	COMPRESSION	DEFLECTION	LOAD	Xi+ AFT OR DOWN SLOPE	Y(+ LEFT) Z(+ UP OR HOR- MAL TO SLOPE)	X (+ FORWARD)	Y (+ RIGHT)	Z (+ DOWN)	
1	3	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
2	3	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
3	3	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
4	3	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
5	3	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
6	3	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
7	3	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
8	3	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
9	3	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
10	3	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
11	3	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
12	3	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
13	3	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
14	3	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
15	3	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
16	3	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
17	3	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
18	3	0	4.82097D 00	0.0	1.70589D 05	5.11364D 04	3.16689D 02	1.70458D 05	-5.76055D 04	-1.77376D 03	-1.68373D 05
19	3	0	4.32507D 00	0.0	3.84812D 04	1.15440D 04	0.0	3.84800D 04	-1.18439D 04	0.0	-3.83888D 04

DRI RESULTS: MASS NO. AND DRI VALUE

MASS DRI
 21 1.12790D 00

VEHICLE C.G. TRANSLATIONAL VELOCITIES, GROUND AXES, BASED ON SYSTEM LINEAR MOMENTUM

XDOT YDOT ZDOT
 (+FWD) (+RIGHT) (+DOWN)
 3.12984D 03 0.0 2.67220D 02

ENERGY DISTRIBUTION

TOTAL ENERGY	KINETIC ENERGY	POTENTIAL ENERGY+	STRAIN ENERGY	DAMPING ENERGY	CRUSHING ENERGY	FRICTION ENERGY
2.42972D 09	2.38520D 09	2.50557D 07	1.68450D 06	2.27838D 06	9.07538D 05	1.45927D 07
PERCENT OF TOTAL ENERGY	98.168	1.031	0.069	0.094	0.037	0.601

INTERNAL BEAM

EXTERNAL SPRING

FIGURE 2-23. KRASH85 TIME HISTORY OUTPUT (SHEET 10 OF 11)

MASS	KINETIC ENERGY	PCT	POTENTIAL ENERGY +	PCT	I J	I	J	M	N	STRAIN ENERGY	PCT	DAMPING ENERGY	PCT	I K M	CRUSHING ENERGY	PCT	FRICTION ENERGY	PCT
1	2.0200 07	0.8	2.3520 05	0.9	1	1	2	0	0	1.9830 00	0.0	2.4280 01	0.0	1 3 0	0.0	0.0	0.0	0.0
2	1.1560 08	4.8	1.3160 06	5.3	2	2	3	0	0	5.9850 02	0.0	3.3240 01	0.0	2 3 0	0.0	0.0	0.0	0.0
3	1.9500 08	8.2	2.0360 06	8.1	3	3	4	0	0	1.7090 03	0.1	8.8850 01	0.0	3 3 0	0.0	0.0	0.0	0.0
4	1.6740 08	7.0	1.7180 06	6.9	4	4	5	0	0	1.5370 03	0.1	8.1720 01	0.0	4 3 0	0.0	0.0	0.0	0.0
5	2.7820 08	11.7	2.6500 06	10.6	5	5	6	0	0	1.5100 05	9.0	6.4030 02	0.0	5 3 0	0.0	0.0	0.0	0.0
6	1.0100 08	4.2	1.0220 06	4.1	6	6	7	0	0	3.1280 04	1.9	8.4820 01	0.0	6 3 0	0.0	0.0	0.0	0.0
7	1.1760 08	4.9	1.1300 06	4.5	7	7	8	0	0	2.3800 04	1.4	1.9270 02	0.0	7 3 0	0.0	0.0	0.0	0.0
8	1.2710 08	5.3	1.3170 06	5.3	8	8	9	0	0	5.0180 03	0.7	1.2050 02	0.0	8 3 0	0.0	0.0	0.0	0.0
9	7.2800 07	3.1	9.2810 05	3.7	9	9	10	0	0	6.0270 02	0.0	6.0360 01	0.0	9 3 0	0.0	0.0	0.0	0.0
10	7.8590 07	3.3	7.6520 05	3.1	10	5	11	0	1	6.9280 05	41.1	1.5870 04	0.7	10 3 0	0.0	0.0	0.0	0.0
11	2.4700 08	10.4	2.4850 06	9.9	11	11	12	1	0	3.0780 04	1.8	5.2460 03	0.2	11 3 0	0.0	0.0	0.0	0.0
12	2.5770 08	10.8	3.1790 06	12.7	12	12	13	0	0	1.8920 04	1.1	1.6830 03	0.1	12 3 0	0.0	0.0	0.0	0.0
13	1.3540 08	5.7	1.9120 06	7.6	13	13	14	0	0	2.2940 04	1.4	7.4420 02	0.0	13 3 0	0.0	0.0	0.0	0.0
14	9.6080 07	4.0	1.4870 06	5.9	14	14	15	0	1	2.0220 04	1.2	5.1530 01	0.0	14 3 0	0.0	0.0	0.0	0.0
15	3.9230 07	1.6	5.9090 05	2.4	15	12	16	1	1	5.2400 03	0.3	7.7430 02	0.0	15 3 0	0.0	0.0	0.0	0.0
16	1.3870 08	5.8	9.2340 05	3.7	16	14	17	1	1	4.2830 02	0.0	6.7120 01	0.0	16 3 0	0.0	0.0	0.0	0.0
17	1.3250 08	5.6	1.1360 06	4.5	17	11	18	2	0	3.4690 05	20.6	2.2270 06	97.7	17 3 0	0.0	0.0	0.0	0.0
18	4.8810 07	2.0	5.6960 04	0.2	18	11	18	3	0	1.8890 05	10.7	-4.0990 03	-0.2	18 3 0	8.2590 05	91.0	1.4160 07	97.0
19	2.8540 06	0.1	2.8860 03	0.7	20	6	12	0	0	3.8990 04	2.3	9.5280 02	0.0	19 3 0	8.1690 04	9.0	4.3250 05	3.0
20	1.2810 07	0.5	1.6410 05	0.0	21	9	14	0	0	6.0050 04	3.6	1.7780 02	0.0					
21	0.0	0.0	0.0	0.0	22	12	0	0	0	4.2500 03	0.3	9.7830 02	0.0					
					23	2	20	0	0	3.1820 01	0.0	2.2490 01	0.0					
					24	2	21	0	0	0.0	0.0	0.0	0.0					
					25	15	16	0	0	0.0	0.0	0.0	0.0					
					26	15	16	2	2	0.0	0.0	0.0	0.0					
					27	15	0	0	0	7.4110 03	0.4	1.8570 01	0.0					
					28	15	0	2	0	2.7760 04	1.6	1.8570 01	0.0					

DEVIATION OF TOTAL ENERGY OF EACH MASS FROM 100 PERCENT

MASS	DEVIATION(PERCENT)
1	0.001197
2	0.001206
3	0.001039
4	0.000793
5	0.000535
6	0.000738
7	0.000840
8	0.001039
9	0.001200
10	0.001944
11	0.000318
12	0.000793
13	0.001573
14	0.001386
15	0.001543
16	0.000223
17	0.001563
18	-0.018055
19	0.001381
20	0.000312
21	0.0

FIGURE 2-23. KRASH85 TIME HISTORY OUTPUT (SHEET 11 OF 11)

the angular velocity of mass I, using the same sign convention as for the Euler angles. PDOT, QDOT and RDOT are the body axes components of the angular accelerations of mass I. None of these orientation quantities is output for the node points, since these are the same as for the mass to which a given node point is attached.

XIMPULSE, YIMPULSE, ZIMPULSE are the accumulated area under the filtered acceleration response curve (G-SEC). Normally the user should plot these data to evaluate its meaning.

2.3.3.2.2 Internal Beam Data. - The STRAIN FORCES and TOTAL FORCES (STRAIN + DAMPING) are both output in the same format. FX, FY and FZ are the forces in beam axes acting upon the beam at the j end of the beam. Equal and opposite forces act upon the beam at the i end. MX is the torsion acting at the j end; again an equal and opposite torsion acts at the i end. MYI and MYJ are the bending moments at each end of the beam, acting about the beam y axis. MZI and MZJ are the moments acting about the beam z axis. In general, the moments acting at the i and j ends of the beam are not equal. The i and j ends of the beam are at masses i and j, unless the beam connects to a node point. In this case the i end of the beam is actually located at node point I, M, and the j end at node point J, N. M or N equal to zero means there is no node point; direct mass connection is used. The sign convention for these loads is shown in figure 2-18.

The total beam forces can also be output in a format which shows, for each beam, the loads acting at the I and J masses. This output is titled COMPONENTS OF TOTAL BEAM FORCES ACTING ON MASSES I AND J. For each beam the first line of output shows the forces on mass I, the second line shows mass J. These loads are positive forward, right and down, in mass axes, with moments using right-hand-rule about those axes. The loads are those acting on the masses, not the loads acting on the beams.

The beam X, Y and Z deflection data are presented in relative form, i.e., the values represent deflections at the j end minus those at the i end. The beam rotation data are given in both (J-I) and (J+I) terms. This is done

because the strain forces are calculated using both sum and difference terms. Note that these angles are all in degrees, rather than radians. If the actual rotations at the j and i beam ends are desired, they can be calculated from the output data as

$$\text{THETA}(J) = \frac{\text{THETA}(J+1) + \text{THETA}(J-1)}{2}$$

$$\text{THETA}(I) = \frac{\text{THETA}(J+1) - \text{THETA}(J-1)}{2}$$

Similar equations apply to PSI.

The beam lateral deflections Y and Z which are printed out are not simply the (J-1) values. The θ and ψ rotations of mass I cause Z and Y deflections at end J, which in themselves cause no beam loads. These deflection components are removed from the output deflections. The output deflections are the following

$$Y_{\text{output}} = (Y_j - Y_i) - l * \psi_i$$

$$Z_{\text{output}} = (Z_j - Z_i) + l * \theta_i$$

The Euler angles defining the current orientation of the beam axes are also output in degrees. The column of integers titled VBM define which beams, if any, are treated as vertical beams. For vertical beams, VBM=1; for normal beams, VBM=0. For normal beams, the following procedure is used to determine the current beam axes orientation.

- Start with the ground fixed axis system, with X positive forward, Y positive right and Z positive downward.
- Rotate PSI degrees about the Z axis, using right-hand-rule for positive rotations.
- Rotate THETA degrees about the new rotated Y axis, using right-hand-rule for positive rotations.

For vertical beams (VBM=1), the same procedure is used, but the initial orientation of the X, Y, Z axis is different. In this case, the initial orientation is X positive up, Y positive right and Z positive forward.

For either axis orientation system, there is actually a final rotation of PHI about the X axis. PHI is not shown primarily due to output format line width limitations. However, PHI is normally rather small and will not affect the user's interpretation of the orientation of the beam axes.

2.3.3.2.3 External Spring Data. - For each external spring, the spring compression in inches and compression load in pounds is output. These are along the spring axis, which is oriented parallel to one of the mass axes. The ground deflection is also shown; this deflection will be zero if the ground flexibility is input as zero. The ground contact point loads are given in two coordinate systems, ground axes and mass axes. If the spring in question is on a slope, then slope axes are used instead of ground axes. The output titles for these quantities are self-explanatory.

2.3.3.2.4 DRI and c.g. Velocity Data. - For each beam element which has been defined as a Dynamic Response Index (DRI) type element, the J mass and DRI number are shown. Volume I, Section 1.3.12 explains the theory and usage of DRI elements.

The overall vehicle c.g. velocities, in ground axes, are always output. These velocities are calculated such that the total vehicle weight, with these velocity components, would yield the same linear momentum as that existing in the total system of NM masses. Section 1.3.9 of Volume I explains how these values are derived. This output, particularly the time-history plot of same, is a very useful indicator of the overall vertical motion of the system. Since the system kinetic energy is a scalar quantity, there is no way to separate the kinetic energy due to horizontal motion from that due to vertical motion. Therefore, for analyses in which the horizontal velocity is much larger than the vertical, system kinetic energy is not very useful in determining when the vertical impact velocity has been absorbed. The vertical component of the overall c.g. velocity can be used for this purpose.

2.3.3.2.5 Energy Distribution Data. - The first output in this section of data shows the current total system energy, kinetic energy, potential energy, strain energy, damping energy, crushing energy and friction energy. The next section of output shows the contributions of the individual masses, internal beams and external springs to these system totals. The system kinetic energy should reduce to zero at the conclusion of the analytical run. From a practical standpoint, however, one can expect individual elements to oscillate slightly after the vehicle comes to rest, leaving some residual kinetic energy in the system long after the responses of interest have occurred. In general, it is anticipated that if the analysis shows a 75 percent reduction in kinetic energy, the most significant events will have been adequately described.

If the vehicle is impacting on a flat surface (no slope) and a substantial portion of the initial kinetic energy is due to forward velocity (parallel to the ground), then a much larger percentage of the initial kinetic energy may remain after the significant damage phase of the crash. The remaining energy is accounted for by the vehicle sliding along the ground with a substantial forward velocity. In this case, the vehicle cg translational velocities, printed earlier, provide a better indication of whether the major response phase has been adequately covered. In general, the ZDOT or vertical vehicle translational velocity should be reduced to zero, indicating that the vehicle has ceased its downward motion. This situation can also be seen when the system potential energy reaches a minimum.

The potential energies include the effects of user-defined input time histories of either loads or accelerations, applied to specified masses. That is the significance of the (+) at the end of the POTENTIAL ENERGY headings. Earlier versions of KRASH did not include the effects on the energy balance of the loads or acceleration input. These versions do not have the (+) in the potential energy heading.

The individual internal beam strain energies provide the user with valuable insight into the temporal and spatial flow of energy in the vehicle.

Generally speaking, the strain energy concentrates initially near the point of impact, and as the strain energy grows it also becomes diffused throughout the vehicle. After the peak responses in the system occur, the overall system strain energy will decrease from its peak value as the internal beam elements unload.

Certain individual nonlinear beam elements may indicate negative strain energy. This circumstance may occur when large deflection loading and unloading occurs in the coupled bending degrees of freedom ($z-\theta$ or $y-\phi$), with nonlinear KR curves applied to these directions. This phenomenon is discussed in Section 1.3.16 of Volume I, and is due to the approximate nature of the nonlinear element analytical model. In practice, these negative strain energies are of such small magnitude relative to the overall system strain energy (usually less than 1 percent) that they do not invalidate the overall analysis. Furthermore, these negative energies tend to occur toward the end of the analysis, during the unloading phase, after the primary responses and damage of interest have been determined. The plastic hinge option should be used in lieu of KR tables in the coupled bending directions; negative strain energy will not occur with the plastic hinge option. It should also be noted that negative strain energy does not occur for linear beam elements, or for those that are nonlinear only in the uncoupled degrees of freedom (axial and torsion).

The damping energy of the internal beams is usually small in relation to the strain energy, typically being less than 20 percent of the strain energy, until late in the run when the strain energy has decreased substantially from its peak value. Note that damping energy always increases with time, since it is a dissipative energy that is not stored and released as with strain energy.

Crushing and friction energies result from the deformation of the external springs and flexible ground for the former, and from sliding friction along the ground for the latter. The friction energy is also dissipative

and hence monotonically increasing, whereas the crushing energy peaks and decreases similar to the strain energy. In general, a rather large percentage of the total system energy may be represented by the crushing energy. This situation is only natural since the external springs represent the structure in immediate contact with the ground that undergoes substantial deformation. In a typical vehicle crash analysis, the system crushing energy may be larger than the internal beam strain energy. However, they both represent actual airplane structure, the only distinction being location on the vehicle.

The final energy information printed is a summary of the deviation of the total energy of each mass in the system from 100 percent. Ideally these variations should all be zero, but in actual practice errors associated with the numerical integration process result in deviations from the ideal. This information can be helpful for pinpointing areas of the mathematical model that may be causing numerical accuracy problems, and alerting the program user to the possible need for a finer integration time step.

In typical applications, a few individual mass total energies may deviate 2 to 5 percent from the 100 percent ideal, while the total energy of the entire system remains within 0.5 percent or less. This accuracy is generally considered acceptable for the numerical integration process. However, the program user is free to adjust the integration time step to suit his own personal criterion for the accuracy of the individual mass integrations.

2.2.3.2.6 Internal Beam Stress Data. - The stress data output are shown in figure 2-24, which is taken from the $t = 0$ output of the sample case. (Stress data output was not selected for the sample case, so none was output at $t = 0.5$ used for figure 2-23. At time zero, all output is printed regardless of what the user requests).

This output consists of ratios of current stress to failure level stress (corresponding to initial yielding), for four locations on each beam, using two failure theories. These theories are the maximum shear stress theory and the theory of constant energy of distortion. Section 1.3.17 of Volume 1 presents the method of calculating these ratios. Also shown in the output are the

ratios of current compressive/tensile stress to the corresponding yield stress, and the ratio of current axial compressive load (when it is compressive) to the critical buckling load.

The stress data can be used as a guide for estimating the time at which the element begins to yield. When such a state is reached, a stiffness reduction factor (KR) may be developed for the affected member which then can be used to approximate the nonlinear response characteristics of that member. The user is cautioned to exercise extreme care in the interpretation of data presented in the summary since they do not include the effect of stress concentrations, geometric shape factors, and detail attachment practices at joints. In addition, limitations of the program require that gross regions of the vehicle structure be modeled using relatively simple structural elements. Thus, the more gross the structural region the less accurate the stress values. Also monitoring the response of a structural element which may exhibit a buckling mode of failure will require special consideration. In this case the critical buckling load becomes significant and a stiffness reduction factor should be developed which will approximate the buckling characteristics of the element.

Furthermore, the user should realize that once an element has yielded or buckled, the failure theories followed become invalid and, consequently, the most meaningful use of the stress data is to identify which element may fail and at what point in time such failures are apt to occur.

2.3.3.2.7 Initial Mass Acceleration Error Output. - Figure 2-24 shows this output for the sample case. This information is only output at time zero, and has significance only if balanced initial conditions are used (KRASHIC and MSCFRAN are used to calculate balanced internal beam loads). For each mass in the system, the difference between the actual time zero acceleration calculated in KRASH85 and the theoretically correct value, based on airplane rigid body accelerations at time zero, is printed. A summary at the bottom shows the largest value and corresponding mass number for each of the six accelerations.

KRASH 85 USER'S GUIDE - INPUT/OUTPUT FORMAT(U)
LOCKHEED-CALIFORNIA CO BURBANK M A GAMON ET AL. JUL 85
LR-30777 DOT/FAA/CT-85-10 DTFA03-83-C-00004

ML

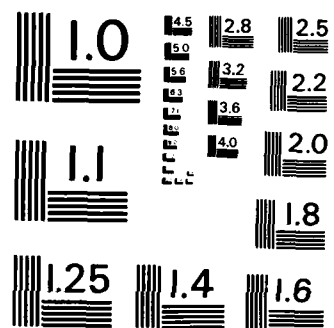
F/G 1/3

NL

FND

FILED

DTIC



MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

25 15 16 0 0 0.0 0.0 0.0 0.0
 26 15 16 2 2 0.0 0.0 0.0 0.0
 27 15 0 0 7.36D 03 2.1 1.118D-15 0.0
 28 15 0 2 0 2.92D 04 8.2 1.118D-15 0.0

DEVIATION OF TOTAL ENERGY OF EACH MASS FROM 100 PERCENT

MASS DEVIATION(PERCENT)

1 0.0
 2 0.0
 3 0.0
 4 0.0
 5 0.0
 6 0.0
 7 0.0
 8 0.0
 9 0.0
 10 0.0
 11 0.0
 12 0.0
 13 0.0
 14 0.0
 15 0.0
 16 0.0
 17 0.0
 18 0.0
 19 0.0
 20 0.0
 21 0.0

ELEMENT STRESSES

BEAM				RATIO OF CURRENT STRESS / FAILURE STRESS				THEORY OF CONSTANT ENERGY OF DISTORTION				RATIO OF CURRENT AXIAL/FAILURE BUCK. /			
				MAXIMUM SHEAR STRESS THEORY				TOP BOTTOM LEFT RIGHT				COMPR. TENSILE CR BUCK. LOAD			
I	J	M	N	TOP	BOTTOM	LEFT	RIGHT	TOP	BOTTOM	LEFT	RIGHT	STRESS	STRESS	STRESS	LOAD
1	1	2	0	6.636D-03	6.636D-03	3.980D-03	3.980D-03	6.446D-03	6.636D-03	3.446D-03	3.446D-03	1.849D-07	2.810D-10		
2	2	3	0	7.081D-02	7.173D-02	2.654D-02	2.654D-02	6.878D-02	7.173D-02	2.298D-02	2.298D-02	4.625D-04	1.714D-06		
3	3	4	0	1.092D-01	1.095D-01	5.850D-02	5.850D-02	1.060D-01	1.095D-01	5.073D-02	5.073D-02	1.873D-04	6.916D-07		
4	4	5	0	1.462D-01	1.470D-01	4.779D-02	4.779D-02	1.420D-01	1.470D-01	4.159D-02	4.159D-02	3.898D-04	3.411D-06		
5	5	6	0	2.696D-01	3.181D-01	4.587D-02	4.587D-02	2.619D-01	3.181D-01	4.153D-02	4.153D-02	2.426D-02	1.047D-04		
6	6	7	0	2.432D-01	2.952D-01	6.616D-02	6.616D-02	2.362D-01	2.952D-01	5.875D-02	5.875D-02	2.600D-02	2.875D-05		
7	7	8	0	2.241D-01	2.921D-01	5.563D-02	5.563D-02	2.177D-01	2.921D-01	5.113D-02	5.113D-02	3.401D-02	1.174D-04		
8	8	9	0	1.496D-01	2.356D-01	4.960D-02	4.960D-02	1.424D-01	2.356D-01	4.839D-02	4.839D-02	4.454D-02	2.369D-04		
9	9	10	0	7.562D-02	8.609D-02	8.166D-02	8.166D-02	7.347D-02	8.609D-02	7.077D-02	7.077D-02	5.228D-03	5.442D-05		
10	10	11	0	1.052D-01	1.209D-01	9.239D-02	9.239D-02	8.979D-02	1.068D-01	8.145D-02	8.007D-02	4.754D-02			
11	11	12	0	5.757D-02	8.125D-02	6.156D-02	6.156D-02	4.802D-02	7.633D-02	5.797D-02	5.555D-02	5.056D-02			
12	12	13	0	1.763D-02	5.118D-02	4.083D-02	4.083D-02	1.528D-02	4.918D-02	3.594D-02	3.444D-02	1.931D-02			
13	13	14	0	2.524D-02	3.831D-02	3.459D-02	3.459D-02	2.346D-02	3.650D-02	3.330D-02	3.260D-02	2.700D-02			
14	14	15	0	2.141D-01	1.992D-01	1.106D-01	8.115D-02	1.881D-01	1.719D-01	1.073D-01	7.860D-02	9.226D-02			
15	15	16	1	1.446D-02	1.436D-02	4.276D-02	4.275D-02	1.553D-02	1.620D-02	3.468D-02	4.179D-02	4.450D-05			
16	16	17	1	1.361D-02	1.363D-02	4.083D-02	4.084D-02	1.274D-02	1.538D-02	3.312D-02	3.982D-02	1.520D-05	6.626D-07		
17	17	18	2	1.997D-00	1.997D-00	1.997D-00	1.997D-00	1.997D-00	1.997D-00	1.997D-00	1.997D-00	1.997D-00			
18	18	18	3	5.182D-01	5.182D-01	5.179D-01	5.180D-01	5.180D-01	5.181D-01	5.178D-01	5.179D-01	5.176D-01			

FIGURE 2-24. KRASH85 INTERNAL BEAM STRESS DATA AND INITIAL MASS ACCELERATION
 ERROR OUTPUT (SHEET 1 OF 2)

The reason that the time zero accelerations are not "exactly" equal to the theoretically correct values is because the accuracy of the KRASHIC/MSCTAN iterations is limited by the number of significant figures used in the input and output data sets used with NASTRAN. The accuracy shown in figure 2-24 is representative of a typical large transport airplane model, using ten iterations of KRASHIC/NASTRAN. In general the results are quite good, with most translational accelerations accurate to within E-5 g's. Errors of this order should have no appreciable influence on the subsequent time history results, particularly for crash impacts which typically involve mass accelerations of five g's or more.

DRI masses are excluded from the largest value summary because the DRI beam elements always start with zero internal load and deflection in the axial direction. In subroutine NETFOR, where the theoretically exact initial accelerations are computed, it is assumed that the DRI mass is rigidly attached to the vehicle.

2.3.3.3 Summary Output

At the conclusion of the time history printout several summaries are presented, which include:

- Summary of internal beam yielding and rupture
- Summary of mass penetration into a control volume
- Summary of external spring loading and unloading
- Summary of plastic hinge moment formations
- Summary of energy distribution
- Time histories of interaction loads/summary of maximum load ratios
- Time histories of vehicle c.g. motions

The summaries are illustrated in figure 2-25.

Internal beam element yielding and rupture are summarized at the end of the run. For each occurrence of yielding or rupture, the time, beam identification and beam direction of yielding or rupture is output. Directions 1-6

correspond to beam axis directions x , y , z , ϕ , θ and ψ , the latter three being rotations about the beam x , y and z axes. In addition the beam tension and compression rupture is noted. If a beam has a special KR curve that starts at a nonzero value, then this summary will indicate yielding at time zero. This output provides the user with a concise summary of the onset of beam nonlinearities and beam ruptures.

Also included in the internal beam yielding summary are occurrences of interaction loads exceeding the user defined load envelopes. In figure 2-25, SUMMARY OF INTERNAL BEAM YIELDING AND RUPTURE, the first item for beam 18 is a conventional beam yielding in the 1, or axial direction. The second item, for beam 19, is a conventional beam rupture due to exceeding input maximum load levels, again in the axial direction. The third line, for beam 9, is an example of load interaction curve data showing up in this summary. The 15 under YIELD signifies that for load interaction curve number 15, an exceedance of the defined load envelope has occurred. The 3 in the right hand column means that load line number 3, for interaction curve 15, was the specific interaction line that was exceeded. If the input load envelope is exceeded by the factor RUPRAT (See Section 2.2, figure 2-3, card 2800), then the load interaction curve number will be printed under the heading RUPTURE. It should be noted that load interaction curve outputs in the YIELD column have caused nothing to happen in the time history solution; outputs in the RUPTURE column would have triggered an actual beam rupture during the time history solution.

Any mass penetrations into the mass penetration control volume are also summarized. Both the mass penetrating the control volume and time of occurrence are noted. Since MVP = 0 in the sample case, this output is not illustrated in figure 2-25.

The summary of external spring loading and unloading provides the time of occurrence, the spring designations (mass, node, direction), type of event, initial deflection, maximum force and unloaded deflection and force.

The summary of plastic hinge formations identifies the time, beam number and mass number at the end where a plastic hinge formation takes place. In figure 2-25, beam 1 and mass 2 goes through cyclic plastic hinge motion. At

SUMMARY OF INTERNAL BEAM YIELDING AND RUPTURE									
TIME	BEAM			BEAM DIRECTION FOR			TENSION(+) OR		
	I	J	N	YIELD	RUPTURE	COMPRESSION(-)			
0.030700	18	11	18	3	0	1	0		
0.071250	19	2	19	1	0	0	-1		
0.100000	9	9	10	0	0	15	3		

FIGURE 2-25. KRASH85 SUMMARY OUTPUT DATA (SHEET 1 OF 10)

SUMMARY OF EXTERNAL SPRING LOADING AND UNLOADING

TYPES:1=INITIAL LOADING 2=MAX.LOADING 3=UNLOAD TO ZERO FORCE 4=INITIATION OF RELOAD

NOTE:SPRING RELOADS AT ZERO FORCE(SEQ.1,2,3,4) OR AT FINITE FORCE VALUE(SEQ.1,2,4)

NOTE:INITIAL DEFLECTION IS FIRST IMPACT IF NTYPE=1, OTHERWISE IT IS POINT AT WHICH RELOADING OCCUR FOR NTYPE=4

TIME(SEC)	MASS NO.	NODE NO.	DIRECTION L=1,2,3	TYPE NO.	INITIAL DEFLECTION	MAXIMUM FORCE &/OR DEFLECT	UNLOADED DEFLECT & FORCE
0.00050	18	0	3	1	0.0142	0.0	0.0 0.0
0.027150	19	0	3	1	0.0093	0.0	0.0 0.0
0.031250	18	0	3	2	0.0142	0.210 06	5.9281 0.0 0.0
0.031650	18	0	3	2	0.0142	0.210 06	5.9295 0.0 0.0
0.050700	18	0	3	4	4.8176	0.210 06	5.9295 4.8176 0.170 06
0.071350	19	0	3	2	0.0093	0.140 06	6.5908 0.0 0.0
0.071450	19	0	3	2	0.0093	0.140 06	6.5906 0.0 0.0
0.075250	19	0	3	3	0.0093	0.140 06	6.5906 5.2342 0.0
0.080700	18	0	3	2	4.8176	0.330 06	8.4122 4.8176 0.170 06
0.080850	18	0	3	2	4.8176	0.330 06	8.4125 4.8176 0.170 06
0.097750	18	0	3	4	7.2872	0.330 06	8.4125 7.2872 0.220 06

SUMMARY OF PLASTIC HINGE FORMATIONS

TIME	BEAM			BEAM END			DIRECTION-NEWPIN
	I	J	M	I	J	M	
0.061600	1	1	2	0	0	2	5 1
0.064300	1	1	2	0	0	2	5 0
0.068900	1	1	2	0	0	2	-5 1
0.071600	1	1	2	0	0	2	-5 0
0.072300	1	1	2	0	0	2	5 1

TIME	PERCENT MAXIMUM ENERGY DEVIATION	PERCENT TOTAL SYSTEM ENERGY	KINETIC ENERGY	PERCENT OF CURRENT TOTAL	POTENTIAL ENERGY*	PERCENT OF CURRENT TOTAL	STRAIN ENERGY	PERCENT OF CURRENT TOTAL	DAMPING ENERGY	PERCENT OF CURRENT TOTAL	CRUSHING ENERGY	PERCENT OF CURRENT TOTAL	FRICTION ENERGY	PERCENT OF CURRENT TOTAL
0.0	0.0	100.00	2.405E 09	98.9%	2.480E 07	1.02	3.560E 05	0.01	6.407E-11	0.00	0.0	0.0	0.0	0.0
0.01000	0.010%	100.00	2.403E 09	98.91	2.495E 07	1.02	3.586E 05	0.01	5.545E 03	0.00	2.84E 05	0.01	9.687E 05	0.04
0.02000	0.020%	100.00	2.400E 09	98.77	2.491E 07	1.03	4.222E 05	0.02	1.142E 05	0.00	8.536E 06	0.04	3.566E 06	0.15
0.03000	0.030%	100.00	2.395E 09	98.58	2.446E 07	1.03	6.989E 05	0.03	4.218E 05	0.02	1.245E 06	0.05	7.152E 06	0.29
0.04000	0.040%	100.00	2.390E 09	98.38	2.502E 07	1.03	1.192E 06	0.05	1.176E 06	0.05	1.089E 06	0.04	1.100E 07	0.45
0.05000	0.050%	100.00	2.385E 09	98.17	2.506E 07	1.03	1.685E 06	0.07	2.278E 06	0.09	9.075E 05	0.04	1.45E 07	0.65
0.06000	0.060%	100.00	2.380E 09	97.95	2.507E 07	1.03	1.989E 06	0.08	2.942E 06	0.12	1.256E 06	0.05	1.846E 07	0.76
0.07000	0.070%	100.00	2.373E 09	97.68	2.507E 07	1.03	1.951E 06	0.08	3.404E 06	0.14	1.181E 06	0.09	2.385E 07	0.98
0.08000	0.080%	100.00	2.366E 09	97.38	2.507E 07	1.03	1.929E 06	0.08	4.100E 06	0.17	2.702E 06	0.11	2.993E 07	1.23
0.09000	0.090%	100.00	2.359E 09	97.09	2.509E 07	1.02	2.327E 06	0.10	5.186E 06	0.21	2.328E 06	0.10	3.566E 07	1.47
0.10000	0.100%	100.00	2.353E 09	96.86	2.511E 07	1.03	3.032E 06	0.12	6.022E 06	0.25	2.112E 06	0.09	4.002E 07	1.65

LOAD INTERACTION CURVE NO. 1 , BEAM NO. 1
LOCATION: FS= 300.000 , BL= 0.0 , WL= 0.0

TIME	CRITICAL LOAD LINE NUMBER	X LOAD (NO. 3)	Y LOAD (NO. 5)	MAX. LOAD RATIO
0.0	1	1.4432E 03	1.4575E 05	1.0449E-02
0.1000000	1	1.4505E 03	1.4606E 05	1.0492E-02
0.2000000	1	1.2049E 01	1.5838E 05	9.5379E-05
0.3000000	6	4.1271E 02	-1.5248E 04	7.3306E-04
0.4000000	5	5.8028E 02	-7.8524E 04	4.6380E-03
0.5000000	8	8.2173E 02	-7.2334E 04	4.9502E-03
0.6000000	5	1.2858E 02	-7.0516E 04	3.902E-03
0.7099999	4	4.2607E 03	1.9882E 05	2.5771E-02
0.8099998	7	-5.9770E 03	-1.8445E 05	3.6006E-02
1.0899997	2	2.8527E 03	-1.8420E 05	1.8375E-02
3.0999996	8	-9.0518E 02	-1.8431E 05	8.8610E-03
MAXIMUM VALUE:	4	4.2607E 03	1.9882E 05	3.6006E-02
MINIMUM VALUE:	7	-5.9770E 03	-1.8445E 05	

LOAD INTERACTION CURVE NO. 2 , BEAM NO. 2
LOCATION: FS= 300.000 , BL= 0.0 , WL= 0.0

TIME	CRITICAL LOAD LINE NUMBER	X LOAD (NO. 3)	Y LOAD (NO. 5)	MAX. LOAD RATIO
0.0	5	1.0825E 04	1.4968E 05	6.5209E-02
0.000000	5	1.0807E 04	1.4649E 05	6.5583E-02
0.020000	1	7.0436E 03	4.0998E 05	4.9386E-02
0.030000	6	3.2890E 01	4.7372E 04	2.2775E-03

FIGURE 2-25. KRASH85 SUMMARY OUTPUT DATA (SHEET 3 OF 10)

0.04000000 8 -6.8032E 03 -1.3475E 06 6.4784E-02
 0.05000000 7 -2.5080E 04 2.6255E 04 1.510E-01
 0.06000000 7 -4.6627E 04 5.3845E 05 2.808E-01
 0.07000000 7 -6.5402E 04 -1.2800E 06 3.939E-01
 0.08000000 8 2.5365E 02 -6.7244E 06 3.232E-01
 0.09000000 2 5.0925E 03 -8.4343E 05 4.4087E-02
 0.09999996 1 2.7333E 04 1.7523E 06 1.7578E-01
 MAXIMUM VALUE: 2.7333E 04 1.7523E 06 3.939E-01
 MINIMUM VALUE: -6.5402E 04 -6.7244E 06

LOAD INTERACTION CURVE NO. 3, BEAM NO. 2
 LOCATION: FS= 400.000, BL= 0.0, HL= 0.0

TIME	CRITICAL LOAD LINE NUMBER	X LOAD (NO. 3)	Y LOAD (NO. 5)	MAX. LOAD RATIO
0.0	1	1.0825E 04	1.2341E 06	7.8810E-02
0.01000000	1	1.0887E 04	1.2371E 06	7.9195E-02
0.02000000	1	7.0436E 03	1.1158E 06	5.6423E-02
0.03000000	10	3.2890E 01	5.0668E 04	2.1289E-03
0.04000000	8	-6.8032E 03	-2.0291E 06	8.9974E-02
0.05000000	5	-2.5050E 04	-2.4663E 06	1.7646E-01
0.06000000	5	-4.6627E 04	-4.1329E 06	3.2001E-01
0.06999999	5	-6.5402E 04	-7.9327E 06	4.8400E-01
0.07999998	12	2.5365E 02	-6.6995E 06	2.8149E-01
0.08999997	3	5.0925E 03	-3.3379E 05	3.3017E-02
0.09999996	1	2.7333E 04	4.4902E 06	2.2160E-01
MAXIMUM VALUE:	2.7333E 04	4.4902E 06	4.8400E-01	
MINIMUM VALUE:	-6.5402E 04	-7.9327E 06		

LOAD INTERACTION CURVE NO. 4, BEAM NO. 3
 LOCATION: FS= 480.000, BL= 0.0, HL= 0.0

TIME	CRITICAL LOAD LINE NUMBER	X LOAD (NO. 3)	Y LOAD (NO. 5)	MAX. LOAD RATIO
0.0	1	2.3901E 04	2.3625E 06	1.4070E-01
0.01000000	1	2.3359E 04	2.3918E 06	1.3814E-01
0.02000000	1	2.0812E 04	1.8557E 06	1.2097E-01
0.03000000	1	1.7145E 04	1.3406E 05	8.8953E-02
0.04000000	3	1.7726E 04	-1.8144E 06	1.0483E-01
0.05000000	6	5.3162E 03	-4.2406E 06	1.5676E-01
0.06000000	6	1.2085E 04	-7.8305E 06	2.9311E-01
0.06999999	6	5.4359E 04	-1.0317E 07	4.5667E-01
0.07999998	6	3.5852E 04	-4.7208E 06	2.2910E-01
0.08999997	1	3.8774E 04	4.5970E 05	2.0237E-01
0.09999996	2	5.1361E 04	7.1999E 06	3.4332E-01
MAXIMUM VALUE:	5.4359E 04	7.1999E 06	4.5667E-01	
MINIMUM VALUE:	0.0	-1.0317E 07		

LOAD INTERACTION CURVE NO. 5, BEAM NO. 3
 LOCATION: FS= 540.000, BL= 0.0, HL= 0.0

CRITICAL LOAD X LOAD Y LOAD MAX. LOAD

FIGURE 2-25. KRASH85 SUMMARY OUTPUT DATA (SHEET 4 OF 10)

TIME	LINE NUMBER	(NO. 3)	(NO. 5)	RATIO
0.0	1	2.3901E 04	3.7968E 06	1.4776E-01
0.01000000	1	2.3359E 04	3.7935E 06	1.4501E-01
0.02000000	1	2.0812E 04	3.1045E 06	1.2719E-01
0.03000000	1	1.7145E 04	1.1629E 06	9.4626E-02
0.04000000	3	1.7726E 04	-7.5068E 05	9.4544E-02
0.05000000	6	5.3162E 03	-3.9297E 06	1.1522E-01
0.06000000	6	1.2085E 04	-7.1054E 06	2.1014E-01
0.06999999	3	5.4359E 04	-7.0553E 06	3.2455E-01
0.07999998	3	3.5852E 04	-2.5697E 06	1.9888E-01
0.08999997	1	3.8774E 04	2.7860E 06	2.1514E-01
0.09999996	1	5.1361E 04	1.0282E 07	3.3298E-01
MAXIMUM VALUE: 5.4359E 04 1.0282E 07 3.3298E-01				
MINIMUM VALUE: 0.0 -7.1054E 06				

-LOAD INTERACTION CURVE NO. 6 , BEAM NO. 3
LOCATION: FS= 620.000 , BL= 0.0 , WL= 0.0

TIME	CRITICAL LOAD LINE NUMBER	X LOAD (NO. 3)	Y LOAD (NO. 5)	MAX. LOAD RATIO
0.0	2	2.3901E 04	5.7091E 06	1.3381E-01
0.01000000	2	2.3359E 04	5.6624E 06	1.3181E-01
0.02000000	2	2.0812E 04	4.7697E 06	1.1399E-01
0.03000000	2	1.7145E 04	2.5347E 06	7.6405E-02
0.04000000	1	1.7726E 04	6.6759E 05	6.5577E-02
0.05000000	12	5.3162E 03	-3.5045E 06	7.7877E-02
0.06000000	12	1.2085E 04	-6.1387E 06	1.3641E-01
0.06999999	3	5.4359E 04	-2.7067E 06	2.0465E-01
0.07999998	9	3.5852E 04	2.9855E 05	1.3085E-01
0.08999997	2	3.8774E 04	5.8878E 06	1.7474E-01
0.09999996	10	5.1361E 04	1.4391E 07	3.1979E-01
MAXIMUM VALUE: 5.4359E 04 1.4391E 07 3.1979E-01				
MINIMUM VALUE: 0.0 -6.1387E 06				

LOAD INTERACTION CURVE NO. 7 , BEAM NO. 4
LOCATION: FS= 620.000 , BL= 0.0 , WL= 0.0

TIME	CRITICAL LOAD LINE NUMBER	X LOAD (NO. 3)	Y LOAD (NO. 5)	MAX. LOAD RATIO
0.0	2	3.1956E 04	5.7088E 06	1.5476E-01
0.01000000	2	3.2378E 04	5.5624E 06	1.5377E-01
0.02000000	1	3.9180E 04	4.3801E 06	1.6059E-01
0.03000000	9	4.5518E 04	2.3272E 06	1.7169E-01
0.04000000	9	3.4936E 04	5.9864E 05	1.2750E-01
0.05000000	3	5.8597E 04	-3.8165E 06	2.2545E-01
0.06000000	3	1.0030E 05	-6.3104E 06	3.8471E-01
0.06999999	9	1.0682E 05	-2.3249E 06	3.8985E-01
0.07999998	9	1.0936E 05	-6.6179E 05	3.9914E-01
0.08999997	1	1.1516E 05	5.6730E 06	4.3322E-01
0.09999996	2	8.7665E 04	1.3921E 07	4.0273E-01
MAXIMUM VALUE: 1.1516E 05 1.3921E 07 4.3322E-01				
MINIMUM VALUE: 0.0 -6.3104E 06				

FIGURE 2-25. KRASH85 SUMMARY OUTPUT DATA (SHEET 5 OF 10)

LOAD INTERACTION CURVE NO. 8 , BEAM NO. 5
LOCATION: FS= 960.000 , BL= 0.0 , HL= 0.0

TIME	CRITICAL LOAD LINE NUMBER	X LOAD (NO. 3)	Y LOAD (NO. 5)	MAX. LOAD RATIO
0.0	1	2.6029E 04	1.3903E 07	1.8948E-01
0.01000000	1	3.3428E 04	1.3620E 07	1.8410E-01
0.02000000	7	7.7627E 04	1.3860E 07	2.6954E-01
0.03000000	7	1.4105E 05	1.9478E 07	4.8975E-01
0.04000000	7	1.4238E 05	3.0446E 07	4.9932E-01
0.05000000	4	1.7177E 05	3.6874E 07	6.0333E-01
0.06000000	7	2.2831E 05	4.1785E 07	7.9275E-01
0.06999999	2	1.9131E 05	4.7063E 07	7.1118E-01
0.07999998	1	8.7044E 04	5.3087E 07	7.2583E-01
0.08999997	1	1.5296E 05	5.0584E 07	6.7823E-01
0.09999996	2	2.4960E 05	5.6226E 07	8.9400E-01
MAXIMUM VALUE: 2.4960E 05 5.6226E 07 8.9400E-01				
MINIMUM VALUE: 0.0				

LOAD INTERACTION CURVE NO. 9 , BEAM NO. 6
LOCATION: FS= 960.000 , BL= 0.0 , HL= 0.0

TIME	CRITICAL LOAD LINE NUMBER	X LOAD (NO. 3)	Y LOAD (NO. 5)	MAX. LOAD RATIO
0.0	1	3.9302E 04	1.4143E 07	1.9029E-01
0.01000000	1	4.1718E 04	1.4114E 07	1.8950E-01
0.02000000	2	6.3622E 04	1.4524E 07	2.2913E-01
0.03000000	7	1.1614E 05	1.9357E 07	4.0326E-01
0.04000000	7	1.4935E 05	3.0596E 07	5.1859E-01
0.05000000	2	1.6815E 05	3.8531E 07	6.0653E-01
0.06000000	2	2.0004E 05	4.2754E 07	7.0138E-01
0.06999999	2	1.7822E 05	4.8462E 07	6.9276E-01
0.07999998	1	1.1828E 05	5.6003E 07	7.6065E-01
0.08999997	1	1.2290E 05	5.3240E 07	7.2094E-01
0.09999996	2	1.9407E 05	5.8359E 07	7.9092E-01
MAXIMUM VALUE: 2.0004E 05 5.8359E 07 7.9092E-01				
MINIMUM VALUE: 0.0				

LOAD INTERACTION CURVE NO. 10 , BEAM NO. 6
LOCATION: FS=1000.000 , BL= 0.0 , HL= 0.0

TIME	CRITICAL LOAD LINE NUMBER	X LOAD (NO. 3)	Y LOAD (NO. 5)	MAX. LOAD RATIO
0.0	1	3.9303E 04	1.2568E 07	1.8557E-01
0.01000000	1	4.1318E 04	1.2459E 07	1.9174E-01
0.02000000	1	6.3622E 04	1.1974E 07	2.6373E-01
0.03000000	9	1.1614E 05	1.4703E 07	4.5724E-01
0.04000000	1	1.4935E 05	2.4612E 07	6.0381E-01
0.05000000	1	1.6815E 05	3.1794E 07	6.9765E-01
0.06000000	1	2.0004E 05	3.4739E 07	8.1643E-01
0.06999999	1	1.7822E 05	4.1321E 07	7.7277E-01

FIGURE 2-25. KRASH85 SUMMARY OUTPUT DATA (SHEET 6 OF 10)

0.00000000 1 1.140E 05 5.120E 07 6.950E-01
 0.00000000 2 1.120E 05 4.827E 07 6.945E-01
 0.00000000 1 1.940E 05 5.058E 07 8.652E-01
 MAXIMUM VALUE: 2.000E 05 5.120E 07 8.652E-01
 MINIMUM VALUE: 0.0 0.0

LOAD INTERACTION CURVE NO. 11, BEAM NO. 7
 LOCATION: FS=1080.000, BL= 0.0, WL= 0.0

TIME	CRITICAL LINE NUMBER	X LOAD (NO. 3)	Y LOAD (NO. 5)	MAX. LOAD RATIO
0.0	3	2.398E 04	1.002E 07	1.719E-01
0.01000000	3	2.399E 04	1.000E 07	1.715E-01
0.02000000	2	2.550E 04	9.094E 06	1.622E-01
0.03000000	2	4.519E 04	8.514E 06	2.169E-01
0.04000000	2	8.925E 04	1.405E 07	4.027E-01
0.05000000	2	1.090E 05	2.077E 07	5.281E-01
0.06000000	2	1.078E 05	2.182E 07	5.315E-01
0.06999999	2	1.064E 05	2.941E 07	5.982E-01
0.07999998	2	1.129E 05	4.193E 07	7.337E-01
0.08999997	3	8.023E 04	4.304E 07	7.236E-01
0.09999996	3	9.624E 04	3.936E 07	6.762E-01
MAXIMUM VALUE: 1.129E 05 4.304E 07 7.337E-01				
MINIMUM VALUE: 0.0 0.0				

LOAD INTERACTION CURVE NO. 12, BEAM NO. 7
 LOCATION: FS=1160.000, BL= 0.0, WL= 0.0

TIME	CRITICAL LINE NUMBER	X LOAD (NO. 3)	Y LOAD (NO. 5)	MAX. LOAD RATIO
0.0	3	2.398E 04	8.098E 06	1.921E-01
0.01000000	3	2.399E 04	8.073E 06	1.916E-01
0.02000000	3	2.550E 04	7.040E 06	1.729E-01
0.03000000	2	4.519E 04	4.879E 06	1.798E-01
0.04000000	1	8.925E 04	6.871E 06	3.475E-01
0.05000000	2	1.090E 05	1.193E 07	4.382E-01
0.06000000	2	1.078E 05	1.315E 07	4.472E-01
0.06999999	3	1.064E 05	2.090E 07	5.511E-01
0.07999998	3	1.129E 05	3.285E 07	7.986E-01
0.08999997	3	8.023E 04	3.659E 07	8.330E-01
0.09999996	3	9.624E 04	3.162E 07	7.533E-01
MAXIMUM VALUE: 1.129E 05 3.659E 07 8.330E-01				
MINIMUM VALUE: 0.0 0.0				

LOAD INTERACTION CURVE NO. 13, BEAM NO. 8
 LOCATION: FS=1240.000, BL= 0.0, WL= 0.0

TIME	CRITICAL LINE NUMBER	X LOAD (NO. 3)	Y LOAD (NO. 5)	MAX. LOAD RATIO
0.0	12	9.159E 03	6.759E 06	1.931E-01
0.01000000	12	9.126E 03	6.758E 06	1.930E-01

FIGURE 2-25. KRASH85 SUMMARY OUTPUT DATA (SHEET 7 OF 10)

0.04000000 12 0.0150E 03 0.5000E 06 1.8570E-01
 0.02000000 11 0.0000E 02 0.0000E 00 1.5500E-01
 0.00000000 10 1.1000E 04 2.0000E 06 7.6300E-02
 0.00000000 9 3.0000E 04 4.0000E 06 1.0000E-01
 0.00000000 8 2.0000E 04 0.0000E 00 0.0000E-01
 0.00000000 7 4.0000E 04 1.0000E 06 2.7700E-01
 0.00000000 6 7.0000E 04 2.0000E 06 8.0000E-01
 0.00000000 5 0.0000E 04 0.0000E 00 0.0000E-01
 0.00000000 4 0.0000E 04 0.0000E 00 0.0000E-01
 0.00000000 3 0.0000E 04 0.0000E 00 0.0000E-01
 0.00000000 2 0.0000E 04 0.0000E 00 0.0000E-01
 0.00000000 1 0.0000E 04 0.0000E 00 0.0000E-01

MAXIMUM VALUE: 7.0000E 04 3.0000E 07 8.7655E-01
 MINIMUM VALUE: 0.0 0.0

LOAD INTERACTION CURVE NO. 14 , BEAM NO. 8
 LOCATION: FS=1320.000 , BL= 0.0 , WL= 0.0

TIME	CRITICAL LOAD LINE NUMBER	LOAD (NO. 3)	Y LOAD (NO. 5)	MAX. LOAD RATIO
0.0	8	9.1500E 03	6.0100E 06	2.2000E-01
0.01000000	8	9.1200E 03	6.0115E 06	2.2010E-01
0.02000000	8	9.0900E 03	5.9370E 06	2.1820E-01
0.03000000	8	9.0600E 02	4.6030E 06	1.6940E-01
0.04000000	1	1.1800E 04	1.3180E 06	6.5420E-02
0.05000000	1	3.3600E 04	1.4800E 06	2.1130E-01
0.06000000	8	2.0000E 04	7.7410E 06	2.8660E-01
0.07000000	8	4.1530E 04	1.2740E 07	4.6850E-01
0.08000000	2	7.7620E 04	1.5980E 07	6.1980E-01
0.09000000	8	7.9500E 04	2.2000E 07	8.4200E-01
0.10000000	8	4.9590E 04	2.6200E 07	9.6350E-01
MAXIMUM VALUE:		7.9260E 04	2.6200E 07	9.6350E-01
MINIMUM VALUE:		0.0	0.0	

LOAD INTERACTION CURVE NO. 15 , BEAM NO. 9
 LOCATION: FS=1400.000 , BL= 0.0 , WL= 0.0

TIME	CRITICAL LOAD LINE NUMBER	X LOAD (NO. 3)	Y LOAD (NO. 5)	MAX. LOAD RATIO
0.0	3	2.2000E 04	4.0090E 06	2.3730E-01
0.01000000	3	2.2080E 04	4.0090E 06	2.3730E-01
0.02000000	3	2.2920E 04	4.0190E 06	2.3770E-01
0.03000000	3	1.8050E 04	3.3300E 06	1.9500E-01
0.04000000	1	8.2500E 03	3.4130E 05	6.0500E-02
0.05000000	1	1.2670E 04	-6.3070E 05	1.1410E-01
0.06000000	3	3.0500E 04	5.6770E 06	3.3300E-01
0.07000000	3	4.8500E 04	8.9140E 06	5.2500E-01
0.08000000	3	6.1150E 04	1.0000E 07	5.9210E-01
0.09000000	3	8.5520E 04	1.5600E 07	9.1700E-01
0.10000000	3	8.9170E 04	2.0260E 07	1.1690E 00
MAXIMUM VALUE:		8.9170E 04	2.0260E 07	1.1690E 00
MINIMUM VALUE:		0.0	-6.3070E 05	

SUMMARY OF MAXIMUM LOAD RATIOS

FIGURE 2-25. KRASH85 SUMMARY OUTPUT DATA (SHEET 8 OF 10)

INTERACTION CURVE NO.	BEAM NO.	INT. CURVE LOCATION FS	BL	WL	MAXIMUM LOAD RATIO
1	1	300.000	0.0	0.0	3.6006E-02
2	2	300.000	0.0	0.0	3.9399E-01
3	2	400.000	0.0	0.0	4.8400E-01
4	3	480.000	0.0	0.0	4.5667E-01
5	3	540.000	0.0	0.0	3.3298E-01
6	3	620.000	0.0	0.0	3.1979E-01
7	4	620.000	0.0	0.0	4.3322E-01
8	5	960.000	0.0	0.0	8.9400E-01
9	6	960.000	0.0	0.0	7.9092E-01
10	6	1000.000	0.0	0.0	8.6592E-01
11	7	1080.000	0.0	0.0	7.3371E-01
12	7	1160.000	0.0	0.0	8.3308E-01
13	8	1240.000	0.0	0.0	8.7635E-01
14	8	1320.000	0.0	0.0	9.6353E-01
15	9	1400.000	0.0	0.0	1.1699E 00

OVERALL MAXIMUM LOAD RATIO = 1.1699E 00
CORRESPONDING INT. CURVE NO. = 15

FIGURE 2-25. KRASH85 SUMMARY OUTPUT DATA (SHEET 9 OF 10)

TIME HISTORIES OF VEHICLE CG MOTIONS

TIME	DXI VXI	DVI VVI	DZI VZI	FXI AXI	FVI AYI	FZI AZI
0.0	0.0 3.140000 03	0.0 0.0	0.0 3.000000 02	7.162270-12 -9.884610-03	0.0 0.0	-4.547470-12 2.210540-02
0.010000	3.139760 01 3.139320 03	0.0 0.0	2.993020 00 2.979630 02	5.968610 04 -3.307170-01	0.0 0.0	1.989540 05 -1.044340 00
0.020000	6.278260 01 3.137530 03	0.0 0.0	5.946530 00 2.922270 02	1.059830 05 -5.793210-01	0.0 0.0	3.532770 05 -1.871560 00
0.030000	9.414570 01 3.135010 03	0.0 0.0	8.829120 00 2.840480 02	1.295440 05 -7.051330-01	0.0 0.0	4.318160 05 -2.292570 00
0.040000	1.254820 02 3.132300 03	0.0 0.0	1.162500 01 2.752350 02	1.239400 05 -6.737810-01	0.0 0.0	4.131340 05 -2.192460 00
0.050000	1.567930 02 3.129840 03	0.0 0.0	1.433660 01 2.672200 02	1.138170 05 -6.174340-01	0.0 0.0	3.793960 05 -2.011650 00
0.060000	1.880790 02 3.127290 03	0.0 0.0	1.696830 01 2.588890 02	1.368100 05 -7.382120-01	0.0 0.0	4.560360 05 -2.422510 00
0.070000	2.193350 02 3.123730 03	0.0 0.0	1.950220 01 2.471670 02	2.020740 05 -1.086180 00	0.0 0.0	6.735800 05 -3.588650 00
0.080000	2.505510 02 3.119650 03	0.0 0.0	2.190530 01 2.336760 02	1.981940 05 -1.064900 00	0.0 0.0	6.606480 05 -3.519370 00
0.090000	2.817280 02 3.115800 03	0.0 0.0	2.417600 01 2.209640 02	1.605650 05 -8.633680-01	0.0 0.0	5.352170 05 -2.847060 00
0.100000	3.128710 02 3.112900 03	0.0 0.0	2.633610 01 2.114260 02	1.345290 05 -7.237250-01	0.0 0.0	4.484350 05 -2.381890 00

$t = .0616$, NEWPIN = 1 signifies that the coding has changed from fixed at the j end to pinned at the j end ($j = 2$). This is the technique for forming a plastic hinge. At $t = .0643$, NEWPIN = 0 signifies that unloading has occurred, so that a fixed end condition is appropriate. Subsequent changes in NEWPIN define transition points on a hysteresis curve. NEWPIN = 0 always means a transition to fixed coding has taken place, due to unloading from a plastic hinge moment. NEWPIN = 1 always means that a transition to pinned coding has taken place, due to exceeding the input plastic hinge moment. DIRECTION = 5 in Figure 2-23 refers to moments about the y beam axis (6 would be moment about the z beam axis). DIRECTION = -5 means that the sign of the plastic hinge moment at that time is negative.

The energy summary showing the time variation of the different types of energy is presented. This summary facilitates visualizing the energy flow time variation; the one or two page summary is much easier to read than skimming through the basic time history print, which can run to hundreds of pages. Figure 2-25 shows an example of this output for the sample case. A quick glance at the "PERCENT TOTAL SYSTEM ENERGY" column tells the user how stable the solution is. The percent energy should stay within 99 - 101 percent, preferably within a ± 0.2 percent band. Any significant system instabilities will quickly manifest themselves in this output.

The column entitled "PERCENT MAXIMUM ENERGY DEVIATION" shows the maximum deviation from 100 percent of the total energy for each mass individually, i.e., at each time the worst deviation of all the masses is shown. These numbers will always indicate a greater departure from 100 percent than the "PERCENT TOTAL SYSTEM ENERGY" column, wherein all the masses constituting the system are included. The reason for this situation is that some of the masses have positive and some negative deviations from 100 percent, and when these are summed over the total system cancellations occur. Individual mass total energy deviations in the order of 10 percent may be tolerable, as long as the total system energy is acceptable. In the example shown in figure 2-25, the total system energy remains constant within .01 percent, while the maximum energy deviation is .02 percent at the conclusion of the analysis. The (+) in the heading for POTENTIAL ENERGY signifies that energy changes due to

applied force or acceleration input time histories are included in the numbers shown (refer to Section 2.2.4.2.5).

Time histories of interaction loads follow the energy summary. In the sample case, there are 15 of these time histories, requiring about 5½ pages of output. For each load interaction curve number, the following information is presented versus time:

- X load value, pounds or inch-pounds
- Y load value, pounds or inch-pounds
- Critical load line number. Of all the straight line segments making up the load envelope, the one which is most critical relative to the current X,Y combined loads is indicated. In general, the critical load line number will change with time as the X and Y loads change.
- Maximum load ratio. This is the ratio by which the current load vector length (pt. 0,0 to point X,Y) exceeds a line along this vector but terminating at the intersection of the vector and the critical load line (input). A ratio greater than 1.0 signifies an excursion outside the load envelope defined in the input data.

Each time history data block also includes the identification of the load interaction curve number, beam number and location (FS, BL and WL). Also, the directions of the X and Y loads are defined. In the sample case, the X load is always 3 (vertical shear, Fz) and the Y load is always 5 (bending moment about 7 axis). At the end of each time history data block, the maximum and minimum values of X load and Y load are shown, as well as the peak value of MAX.LOAD RATIO.

After the individual load interaction time histories, a summary of the peak values of the maximum load ratio is shown for all the input curves. This is followed by the overall maximum load ratio and the corresponding interaction curve number. For example, in figure 2-25, the overall maximum load ratio is 1.1699, which occurs for interaction curve number 15. This output gives a very quick indication of the severity of the impact being analyzed. However, maximum load ratios greater than 1.0 do not necessarily imply that the corresponding structural section would have completely failed. Refer to Section 3.1 for a discussion of the theory and usage of the load-interaction data.

If the interaction curves are used to obtain an overall section shear and moment (summation of all loads acting at a particular station) then the aforementioned printed summary is applicable to the sum of the forces acting and not an individual beam.

The final summary print output is a time history of the overall vehicle c.g. motions. The quantities included are

- c.g. translational accelerations, g's
- c.g. translational velocities, in/sec
- c.g. translational displacements, in (= 0 at time = 0)
- Net forces acting at the c.g., pounds

All these data are calculated in the same manner as the c.g. translational velocities, described in Section 1.3.9 of Volume 1. Weighted averages of all the mass motions are used to arrive at a value for the entire system. The final results completely define the translational motions of an uncoupled 1-mass, 3 degree-of-freedom system. Rotational loads and motions are not presented.

These data have been used to determine vertical load-deflection characteristics for a large transport frame structure. Cross plots of DZI vs FZI from the KRASH analysis of a frame structure form a load-deflection curve that can be used to determine the external spring characteristics of a stick model of an entire airplane.

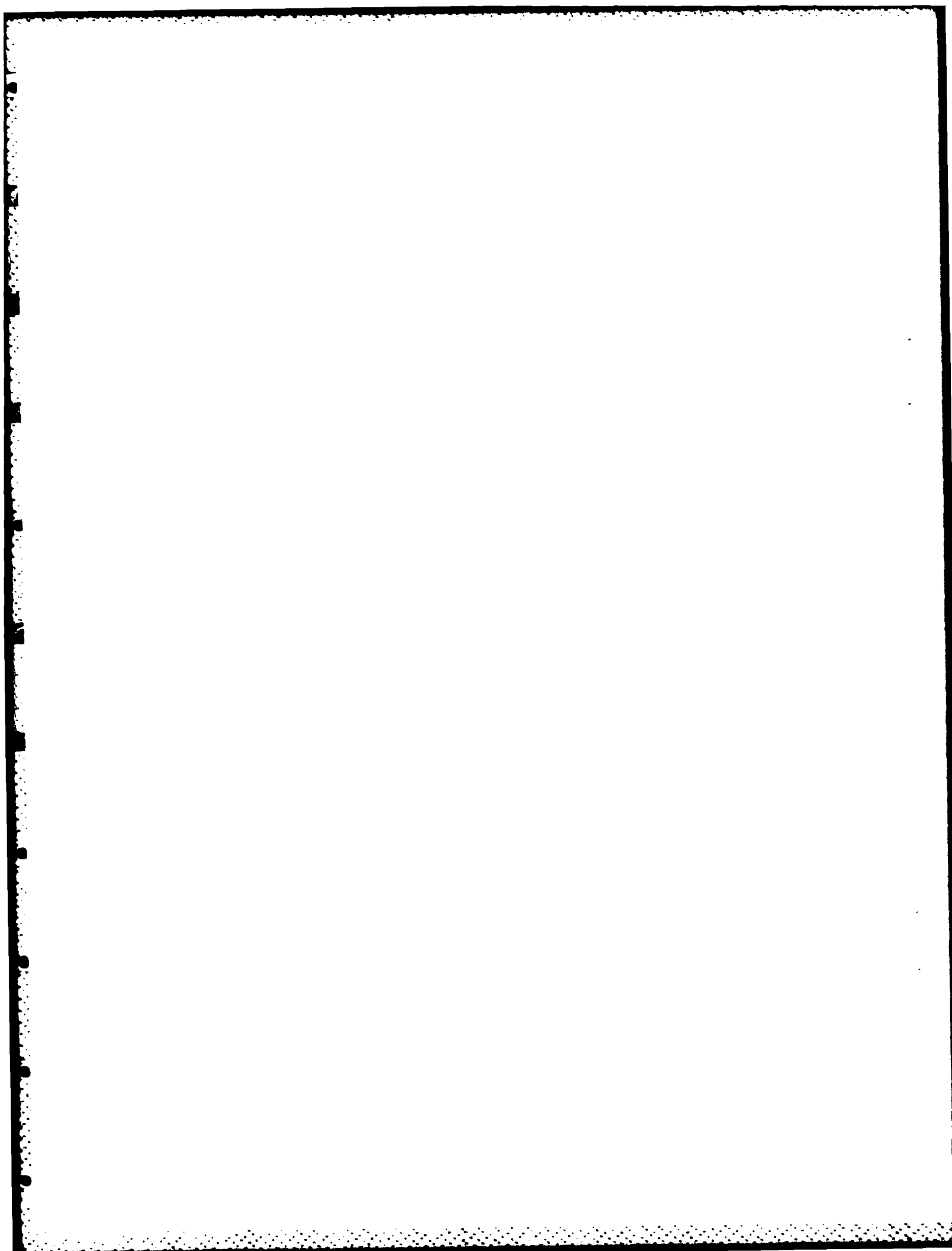
2.3.3.4 Time History Plots

The final section of output data consists of time history plots of selected response quantities. Figure 2-26 illustrates typical output data. The sequential time history print of the three responses is shown on the left, while the plots are generated using three separate printer symbols. The scale factor for all three plots is shown in the upper right corner of the page. The plot summary is printed on a separate output page as are the various sets of data.

BEAM 11 I,M = 11, 1 J,N = 12, 0 AXIAL AND SHEAR FORCES(LB)

TIME(SEC)	FX	FY	FZ	SCALE FACTOR = 1.760E 04
0.0	1.118E 05	2.958E 04	-2.167E 04	*
0.010	1.052E 05	2.512E 04	-1.221E 04	*
0.020	8.173E 04	1.556E 04	1.089E 04	*
0.030	6.175E 04	7.573E 03	1.665E 04	*
0.040	4.526E 04	5.869E 03	1.412E 04	*
0.050	8.538E 03	-6.437E 03	3.082E 04	*
0.060	-1.183E 04	-1.947E 04	3.329E 04	*
0.070	-1.048E 04	-7.815E 03	1.572E 04	*
0.080	9.491E 02	1.251E 04	6.732E 03	*
0.090	4.979E 03	4.551E 03	3.533E 04	*
0.100	2.677E 04	-3.599E 04	7.308E 04	*

FIGURE 2-26. KRASH85 SAMPLE OUTPUT TIME HISTORY PLOTS



SECTION 3

ADDITIONAL KRASH85 DATA REQUIREMENTS

This sections contains a description of those KRASH data requirements that are needed for KRASH85. These requirements are in addition to those items provided in Section 4 of reference 2.

3.1 LOAD-INTERACTION CURVES

KRASH85 has provisions to include load interaction curve data for failure prediction. Figure 3-1 shows a typical set of interaction curves for fuselage bending and shear at a particular airplane fuselage station. Figure 3-2 identifies the stringers at a representative frame location. The input requirements for load-interaction curves are as follows:

- The user can specify interaction curves at a maximum of 40 locations, which can be anywhere. For each curve, either a Fuselage Station, Butt Line, or Water Line (only one) is input, as well as the corresponding beam number in a KRASH model. The location of the interaction curve can be anywhere along a given beam; the user is not restricted to using the end points of the beam. For essentially fore-aft beams, only F.S. is input, while for lateral and vertical beams B.L. and W.L., respectively, are input to define the location of a load interaction curve. For each load interaction curve, the user inputs the following additional information:
 - The two load directions for the interaction curve. In figure 3-1, the abscissa represents vertical shear (direction 3) and the ordinate represents vertical bending moment (direction 5). Any 2 of the 6 loads can be specified.
 - A user-specified load sign convention.
 - Horizontal and vertical load interaction lines (4 total).

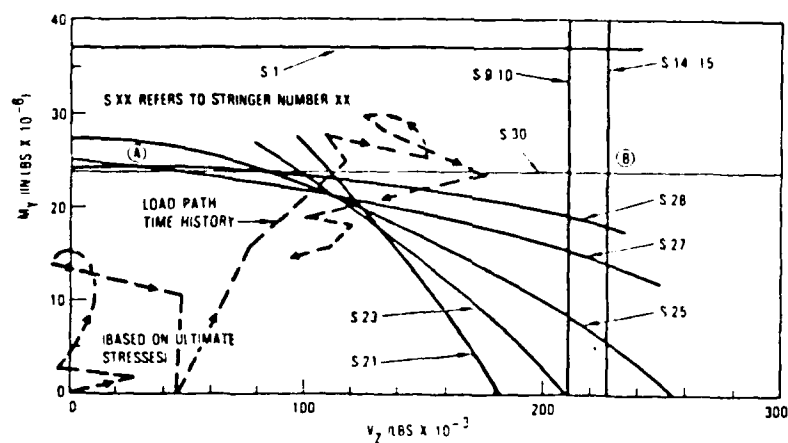


FIGURE 3-1. MAXIMUM ALLOWABLE MOMENT AND SHEAR ENVELOPE - NEGATIVE BENDING

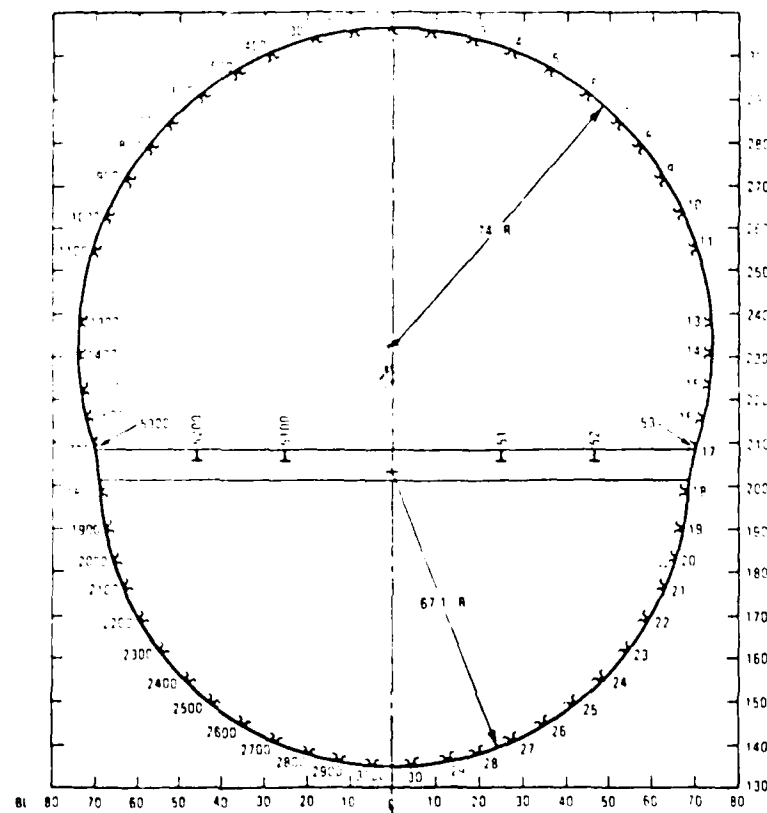


FIGURE 3-2. TYPICAL CROSS SECTION WITH STIFFENER LOCATIONS - REAR VIEW

- Up to 20 straight, sloping load interaction lines. The x and y axis intercepts are input for each line.
- A quantity called RUPRAT (rupture ratio), which is explained below.

The program is coded so that for the sloping interaction lines, data are input for any one quadrant (x and y axis intercepts). In addition, "mirror flags" are input to tell the program whether or not to generate mirror image lines about the x and/or y axes. For example, in figure 3-3 the data are input for line 1 (x and y intercepts), and both the x and y axis mirror flags are input as 1. The program then automatically generates lines 2, 3, and 4. If only a mirror about the y axis had been specified, then the program would generate only line 2.

At each location the program calculates the following:

- The internal beam loads, in KRASH sign convention, at the load interaction point.
 - These loads are transformed to correspond to the standard structural load sign convention employed by the Lockheed-California Company (Calac), shown in figure 3-4.
 - The Calac-convention loads are then transformed to a user-specified sign convention. One of ten such sign conventions may be selected by the user. If no convention is specified, the loads are left in the Calac sign convention.
 - The two interaction loads are selected from the 6 loads calculated.
 - A load ratio for each load interaction line. A ratio greater than one indicates that a load interaction curve has been exceeded, signifying that at least one element has failed in some manner. KRASH is coded to allow complete rupture of a beam element if an input maximum load ratio (RUPRAT) is exceeded.
1. A left handed coordinate system is used; moments employ left hand rule.
 2. Internal loads and moments are positive if the loads or moments applied by the part with the greater algebraic coordinate are positive in accordance with body axes conventions shown as x, y, z.

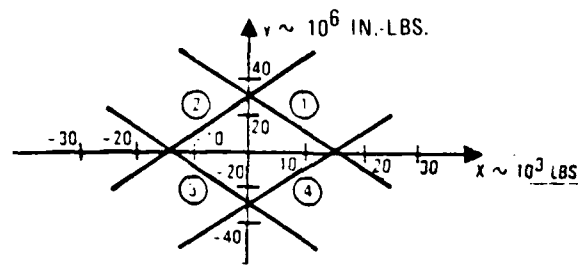


FIGURE 3-3. GENERATION OF LOAD-INTERACTION CURVES

Application of these rules to fuselage and wing loads are shown in the following sketch:

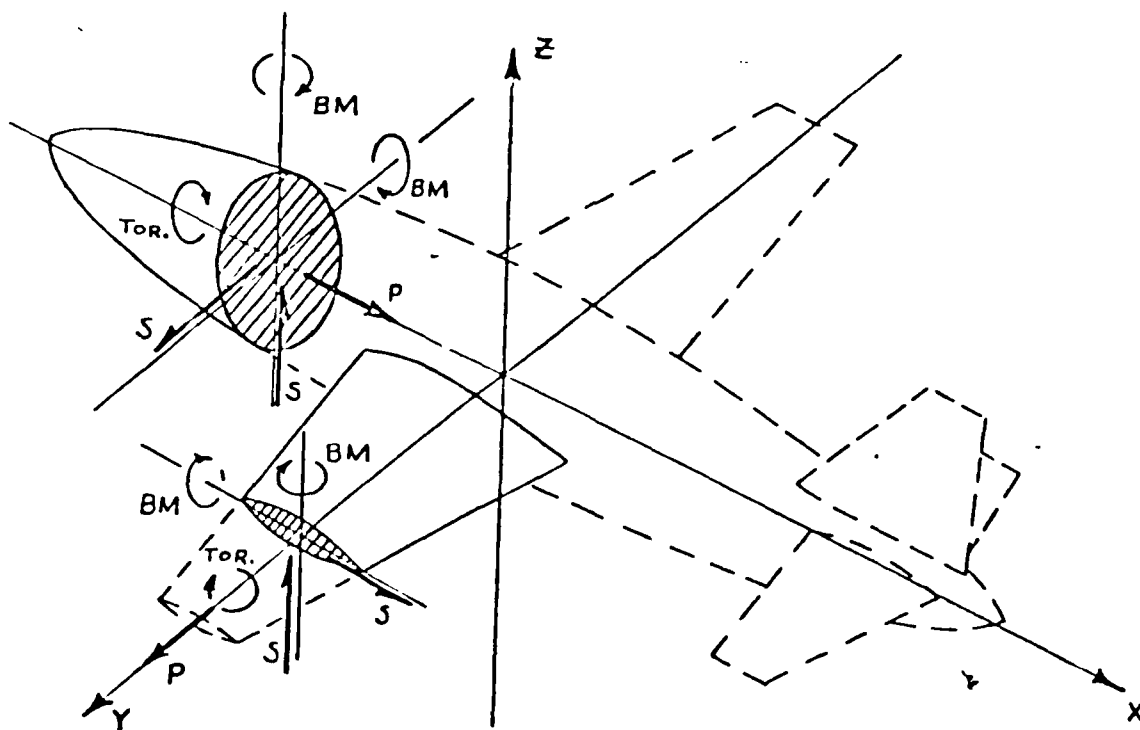


FIGURE 3-4. LOCKHEED LOAD SIGN CONVENTIONS

Loads shown are those applied to the cutplane by the parts with the greater algebraic coordinate (station).

At the conclusion of the computer run the following is printed:

- Time histories of the following quantities for each load interaction curve.
 - X Load (fuselage vertical shear in figure 3-1).
 - Y Load (fuselage vertical bending in figure 3-1).
 - Maximum load ratio at each time.
 - Input load interaction line number corresponding to the maximum load ratio at that time.
- A summary which shows the peak maximum load ratio for each interaction curve and the overall maximum load ratio.

The user has the option of saving the load-interaction curve time history data in an output file, which can be used for subsequent post-processing. These data can be plotted to show the time-varying path of the calculated x-y loads, superimposed on the load-interaction curve (as illustrated by the dashed lines in figure 3-1).

While the load interaction data output provides a great deal of useful information not previously available, considerable caution must be exercised by the user in its interpretation. A maximum load ratio greater than one does not, by itself, indicate complete failure of the corresponding fuselage section. The output data have been used in conjunction with the actual manufacturer-furnished interaction diagrams to assess the extent of damage at each location. For example, suppose that the computed combined loads were as shown by points A or B in figure 3-1. For point A stringers S27 through S30 could fail. For point B several additional stringer elements could fail (S-9 through S-15 and S-21 through S-30). Usually the input data to KRASH is the minimum necessary to define the inner boundary in figure 3-1. The current KRASH85 coding does not define which stringers fail; it only defines the critical load line at each time out.

3.2 ARBITRARY MASS NUMBERING

Program KRASH has been modified to accept user supplied mass point identification numbers. The modification can be thought of conceptually as a mass point number pre-processor and a mass point number post-processor. The pre-processor converts external mass point numbers to internal mass point numbers. The external mass point numbers are supplied by the user as part of the input while the internal mass point numbers are defined by the program. The internal mass numbers are consistent with the numbering system previously used in earlier versions of program KRASH. After conversion program KRASH85 is executed using the internal mass point numbers. After execution is completed the post-processor converts the internal mass point numbers to external mass point numbers for output. In the modification, two new subroutines (INPT and INPTPL) were added. In these subroutines, two arrays (MASS and IMASS) are defined which cross reference the external mass point numbers to internal mass point numbers and vice versa.

The external mass point identification numbers are input in column 71 and 72 on Card 200 (MASS POINT DATA). The identification numbers can not be less than zero or greater than 99. If they are, program execution will be halted. If any of the numbers are left blank or set equal to zero, the program will automatically assign sequential identification numbers to all mass points in the order of input. This option accommodates previously developed input data sets.

When the RUNMOD=2 option is used, the program automatically assigns an external mass point identification number to the image mass point generated under this option. The identification number assigned is 100 greater than the identification number of the mass point used in defining the image mass point. For example, if the input mass point identification number is 96 then the image mass point identification number will be 196.

SECTION 4

COMMON BLOCK REGIONS

KRASH85 is designed such that data storage and transfer is accomplished using the many common block regions defined within the program. A cross reference of the common block names and using subroutines is given in Table 4-1. Included in the cross reference summary are size requirements defined by the FORTRAN H/EXTENDED (OPT = 3) compiler.

TABLE 4-1. KRASH85 SUBROUTINE/Common REGION REFERENCE

SUBROUTINE	A	A	R	C	C	C	G	I	T	T	T	T	T	T	T	K	L	M	N	P	P	R	R	S
COMMON REGION	C	C	F	F	F	F	C	F	C	N	N	N	N	N	N	V	T	A	O	P	P	S	S	M
SIZE	E	E	M	R	I	M	I	P	I	P	P	P	P	P	P	R	C	T	A	X	F	I	N	D
	L	E	N	C	V	J	O	D	T	T	T	T	T	T	T	L	C	L	D	C	I	T	T	A
	T			F																				D
ACCEDE	30	*			*																			
ACCEIR	280	*			*					*														
ACCSAV	CRF4	*			*					*							*							
ACCSV1	10	*			*					*							*							
AERO1	104C	*			*					*							*							
AERK2	F00	*			*					*							*							
AFENER	280	*			*					*							*							
AJJC	4	*			*					*							*							
AVDF	2RA4	*			*					*							*							
AVDFRS	780	*			*					*							*							
BEANDE	4210	*			*			*		*							*							
BKMD	4	*			*					*							*							
BLANK	9980	*			*					*							*							
BOMP	4	*			*					*							*							
CFIC	58	*			*					*							*							
CFINPU	140	*			*					*							*							
CFIP	640	*			*					*							*							
CFPR	R40	*			*					*							*							
COMALL	1COBR	*			*					*							*							*
COMM12	8D4	*			*					*							*							*
COMM14	938	*			*					*							*							*
COMM4	2FD0	*			*					*							*							*
COMM8	480	*			*					*							*							*
CONNEW	1R	*			*					*							*							*
DFLC	260	*			*					*							*							*
DEIN	1022C	*			*					*							*							*
DPINPP	4RB0	*			*					*							*							*
DFIR	12C0	*			*					*							*							*
DEMA	R	*			*					*							*							*
DEPR	67B0	*			*					*							*							*
DINICP	2044	*			*				*								*							*
DCIN	4B0	*			*					*							*							*
DRIFLG	140	*			*					*							*							*
DRIMAS	140	*			*				*								*							*
ENERGY	16BR	*			*					*							*							*
FBPLT	CR	*			*					*							*				*			*
FLGSET	5C	*			*					*							*				*			*
FSIJLJ	3840	*			*					*							*				*			*
GRASAV	R	*			*					*							*				*			*

REFERENCES

1. Gamon, M. A., "KRASH User's Manual; Theory Volume I," FAA-RD-77-189I, Lockheed-California Company, Sept. 1979
2. Gamon, M. A., Wittlin, G., "KRASH User's Manual, Input-Output, Techniques and Applications," Lockheed-California Company, FAA-RD-77-189II (Revised), Sept. 1979

APPENDIX A

SHOCK STRUT ELEMENT DESCRIPTION

A.1 GENERAL

The use of a shock strut element in KRASH is available for, but not limited to, landing gear oleo struts. The following discussion will be oriented to landing gear oleo strut usage. The axial strut motion is assumed to be uncoupled from the transverse displacements. Axial forces are produced by an air spring force, F_{Ai} , a hydraulic damping force, F_{Oi} , a friction force, F_{Fi} , and forces produced by elastic stops which limit the travel of the piston within the cylinder at full extension and full compression. Each of these forces is discussed separately.

A.2 AIR SPRING FORCE

The expression for the air spring force is

$$F_{Ai} = F_{AOi} \left(\frac{E_i}{E_i - y_i} \right)^{n_i} - F_{AAi} \quad (A.1)$$

where

E_i = effective total strut cylinder length (Figure A-1)

F_{AOi} = strut air preload at $y_i = 0$

F_{AAi} = cylinder load due to ambient air

n_i = polytropic exponent

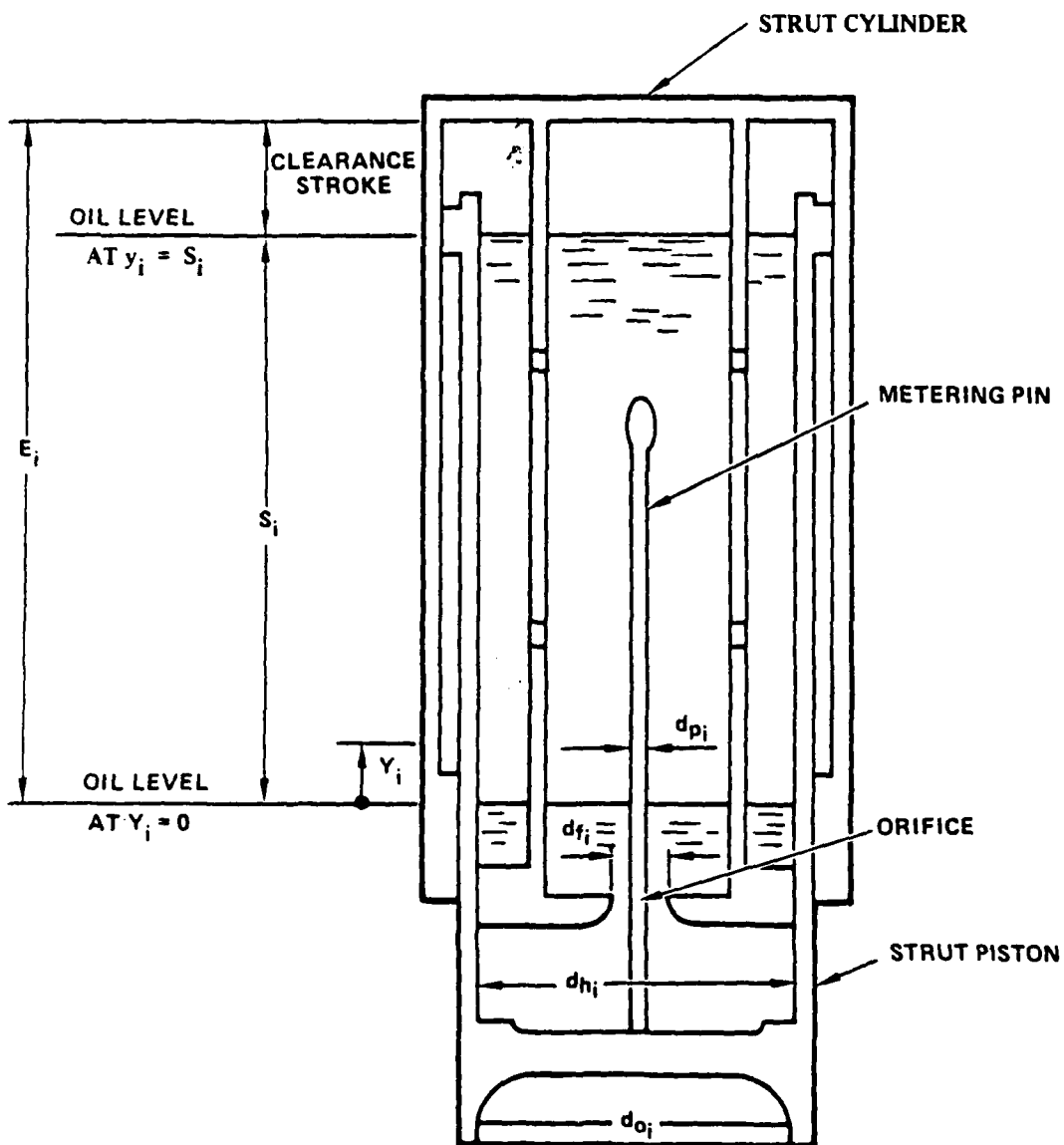


FIGURE A-1. SCHEMATIC OF OLEO STRUT

y_i = shock strut closure displacement, varying with time $F_{A_{oi}}$
is given by

$$F_{A_{oi}} = \pi/4 \left(p_{oi} d_{oi}^2 \right) \quad (A.2)$$

where p_{oi} is the absolute air pressure in the upper chamber of the shock strut at full extension ($y_i = 0$) and d_{oi} is the effective pneumatic diameter as shown in Figure A.1.

If $F_{A_{si}}$ is the strut bottoming load at $y_i = s_i$, the value of E_i can be obtained from equation (A.1) as

$$E_i = \frac{S_i}{1 - \left(\frac{F_{A_{oi}}}{F_{A_{si}} + F_{A_{Ai}}} \right)^{1/n_i}} \quad (A.3)$$

where S_i is the stroke. For high velocity impact conditions, a polytropic exponent of 1.4, representing adiabatic conditions, is appropriate.

In the program the values of E_i , $F_{A_{oi}}$, $F_{A_{Ai}}$, S_i and n_i are input as EOLEO, FAO, FAA, YMAX and EXPOLE, respectively.

A.3 HYDRAULIC DAMPING

The hydraulic damping force F_{oi} is given by

$$F_{oi} = C_{zi} \left| \dot{y}_i \right| \dot{y}_i \quad (A.4)$$

where

$\dot{y}_i$ = shock strut closure velocity, varying with time

$|y_i|$ is the absolute value of y_i and C_{z_i} is a damping constant which is a function of the strut orifice characteristics B_i and of the characteristics B_{r_i} of a strut rebound valve. C_{z_i} is defined as

$$\begin{aligned} C_{z_i} &= B_i \text{ if } \dot{y}_i \geq 0 \\ C_{z_i} &= B_i + B_{r_i} \text{ if } \dot{y}_i < 0 \end{aligned} \quad (A.5)$$

B_i is defined by

$$B_i = \frac{\gamma A_{h_i}^3}{2g (A_{f_i} C_d)^2} \quad (A.6)$$

where

$$A_{f_i} = \pi/4 (d_{f_i}^2 - d_{p_i}^2) = \text{net orifice area}$$

$$C_d = \text{orifice discharge coefficient (typical value} = 0.85)$$

$$\gamma/g = \text{oil density (typical value} = 0.992 \text{ E-4 } \frac{\text{lb-sec}^2}{\text{in}^4})$$

$$A_{h_i} = \pi/4 (d_{h_i}^2) = \text{effective hydraulic area}$$

d_{f_i} , d_{p_i} and d_{h_i} are the orifice, metering pin and effective hydraulic diameters, respective (see Figure A.1).

B_i and B_{r_i} are input into the program as BOLEO and BROLEO. A metering pin can be modeled by inputting a table of BOLEO versus YOLEO. YOLEO is the oleo compression, y , measured from the fully extended position.

Another feature of KRASH is the ability to solve for the metering pin shape that yields a desired oleo load-deflection characteristic curve. If this option is employed, the metering pin input table (POLEO versus YOLEO) is

interpreted as a table of total axial oleo load (F_i in equation A.10) versus oleo compression. This option is termed the inverse metering pin option, and is employed by specifying a negative number for MPTAB on card 1400. The inverse metering pin coding is useful for two situations.

- Landing gear drop data are available, but the basic gear data (metering pin shape) is not. KRASH can be used to calculate the variation of BOLEO versus YOLEO that will duplicate the observed test data, which is used as input data with the inverse metering pin coding. Once the BOLEO vs YOLEO data is calculated and output by KRASH, it can be used as input data for subsequent runs to analyze different conditions involving that gear.
- Metering pin design studies can be conducted using KRASH with the inverse metering pin option. In this situation, a metering pin characteristic can be determined that will yield a specified ideal oleo load-deflection curve.

When the inverse metering pin option is employed, the KRASH output data includes a table of YOLEO vs. BOLEO for each oleo specified. The data point spacing for the table is determined by the output point times specified by DP/DT on card 110. The data will be output in uniform time steps, which means that the YOLEO increments will not be uniform.

A.4 FRICTION FORCE

Coulomb friction is modeled, so that the magnitude of the friction force is independent of velocity, while the direction of the force is opposite to the direction of the strut velocity.

The friction forces, F_{F_i} , are given by

$$F_{F_i} = C_i f(\dot{y}_i) \quad (A.7)$$

where $f(\dot{y}_i)$ is a function whose sign is always equal to that of $\dot{y}_i$ and whose magnitude is 1.

Strictly speaking, $f(\dot{y}_i)$ should be equal to 1.0 for all positive values of $\dot{y}_i$ and equal to -1.0 for all negative values of $\dot{y}_i$. However, since the

friction force is a passive force and is only present as a reaction to an applied force, the friction force will be able to attain its full value only if the applied force is greater than C_i . If this situation is not the case, stops will occur in the motion. A rigorous treatment of this problem would introduce unwarranted complications into the program. A very good approximate solution which avoids the difficulty can be obtained by letting the friction force vary sufficiently slowly from C_i to $-C_i$ at small values of $\dot{y}_i$, so that at each step in the integration process equilibrium of the forces is obtained without introducing large discontinuities. The following form is therefore assumed for $f(\dot{y}_i)$:

$$f(\dot{y}_i) = \tanh (\dot{y}_i/\alpha_o) \quad (A.8)$$

This function is plotted in Figure A-2 for various values of α_o . The value of α_o should be small enough to simulate the friction force with sufficient accuracy, but not so small as to introduce discontinuities. The minimum value will depend on the integration interval. Generally a value of $\alpha_o = 1$ is found to be suitable. The expression for the friction force becomes

$$F_{F_i} = C_i \tanh (\dot{y}_i/\alpha_o) \quad (A.9)$$

The values of α_o and C_i are input as ALPHAP and FCOUL in the program.

A.5 ELASTIC STOPS

Two elastic stops of stiffness K_{E_i} and K_{C_i} are present which limit the travel of the piston at full extension and full compression, respectively. The forces generated by these stops are, therefore, equal to $K_{E_i} Y_i$ when $y_i = 0$ and $K_{C_i} (y_i - S_i)$ when $y_i > S_i$.

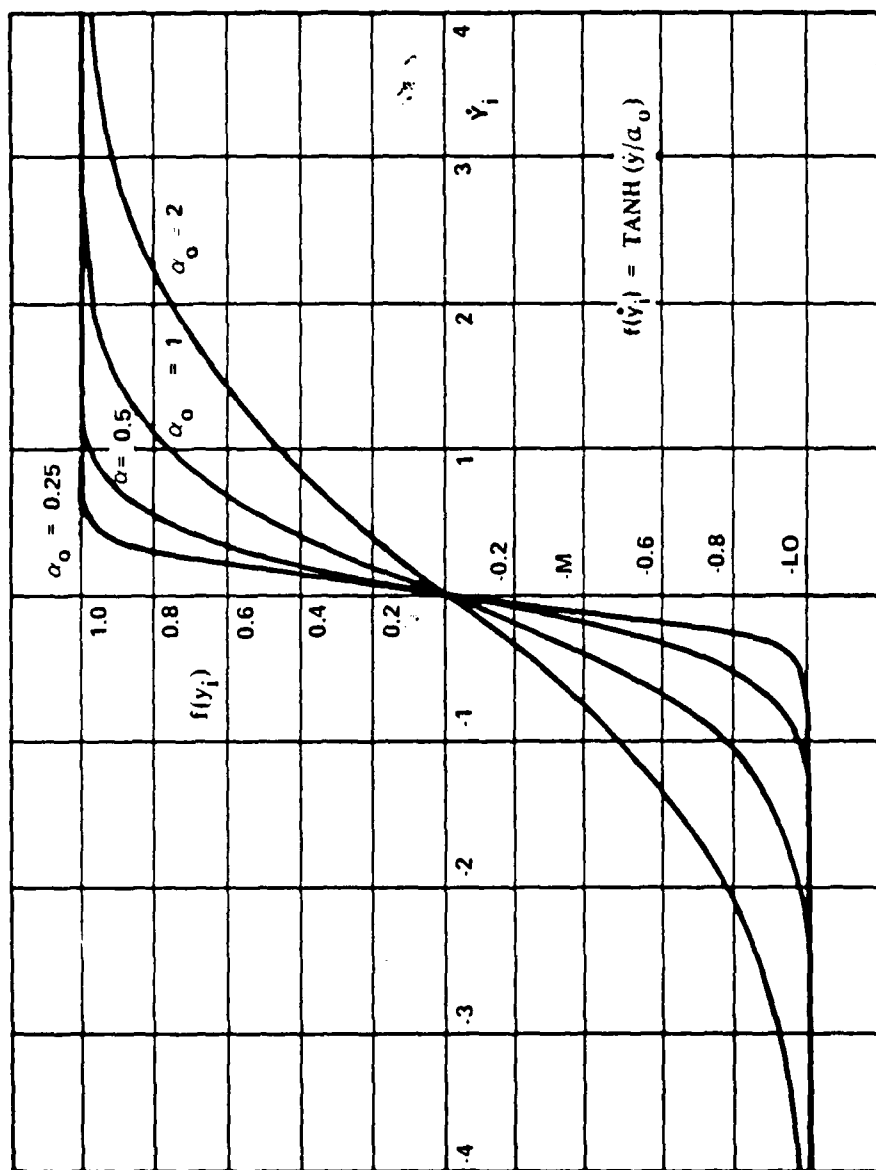


FIGURE A-2. FRICTION FORCE COEFFICIENT AS FUNCTION OF STRUT CLOSURE VELOCITY

Collecting all the above terms the total axial force F_i can be written as

$$F_i = F_{A_i} + F_{O_i} + F_{F_i} + F_{EXT_i} + F_{COMP_i} \quad (A.10)$$

The terms K_{E_i} , K_{C_i} , and S_i are input into the program as XKEXT, XKCOMP, and YMAX, respectively.

END

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