

N 87 - 227 13

**VERIFICATION OF FLEXIBLE STRUCTURES
BY GROUND TEST**

**BEN K. WADA
C. P. KUO**

**Jet Propulsion Laboratory
California Institute of Technology**

**Presented at
Workshop on Structural Dynamics and Control
Interaction of Flexible Structures**

**Sponsor
NASA OAST/MSFC
April 22-24, 1986
Marshall Space Flight Center, Alabama**



PRECEDING PAGE BLANK NOT FILMED

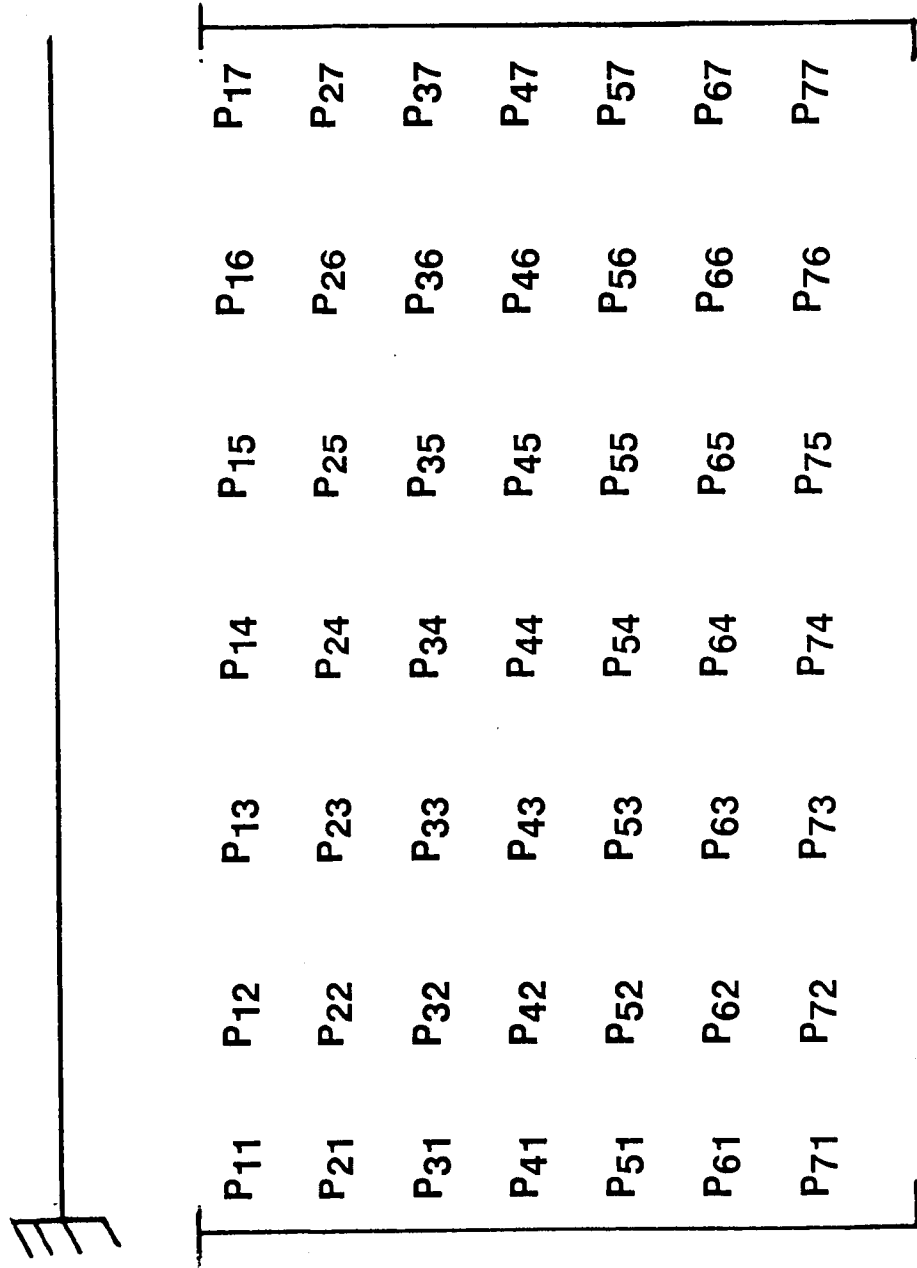
OBJECTIVE

- **Validate Math Models of Large Space Structures by Ground Tests.**

- **Present Concepts for Two Types**
 - **Continuous Type**
 - **Lined Subsystems**

CONTINUOUS TYPE STRUCTURE

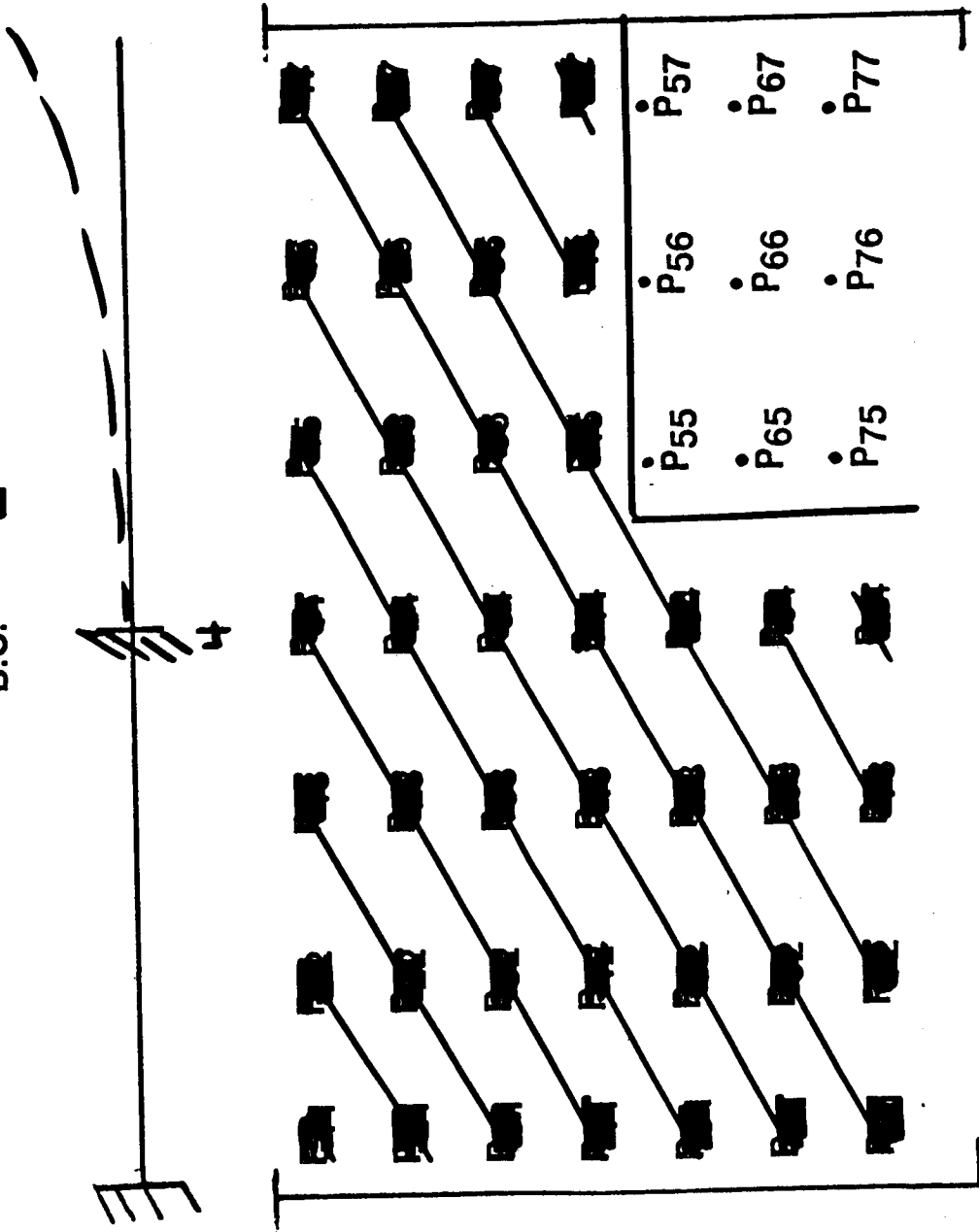
B.C. = -



JPL

CONTINUOUS TYPE STRUCTURE

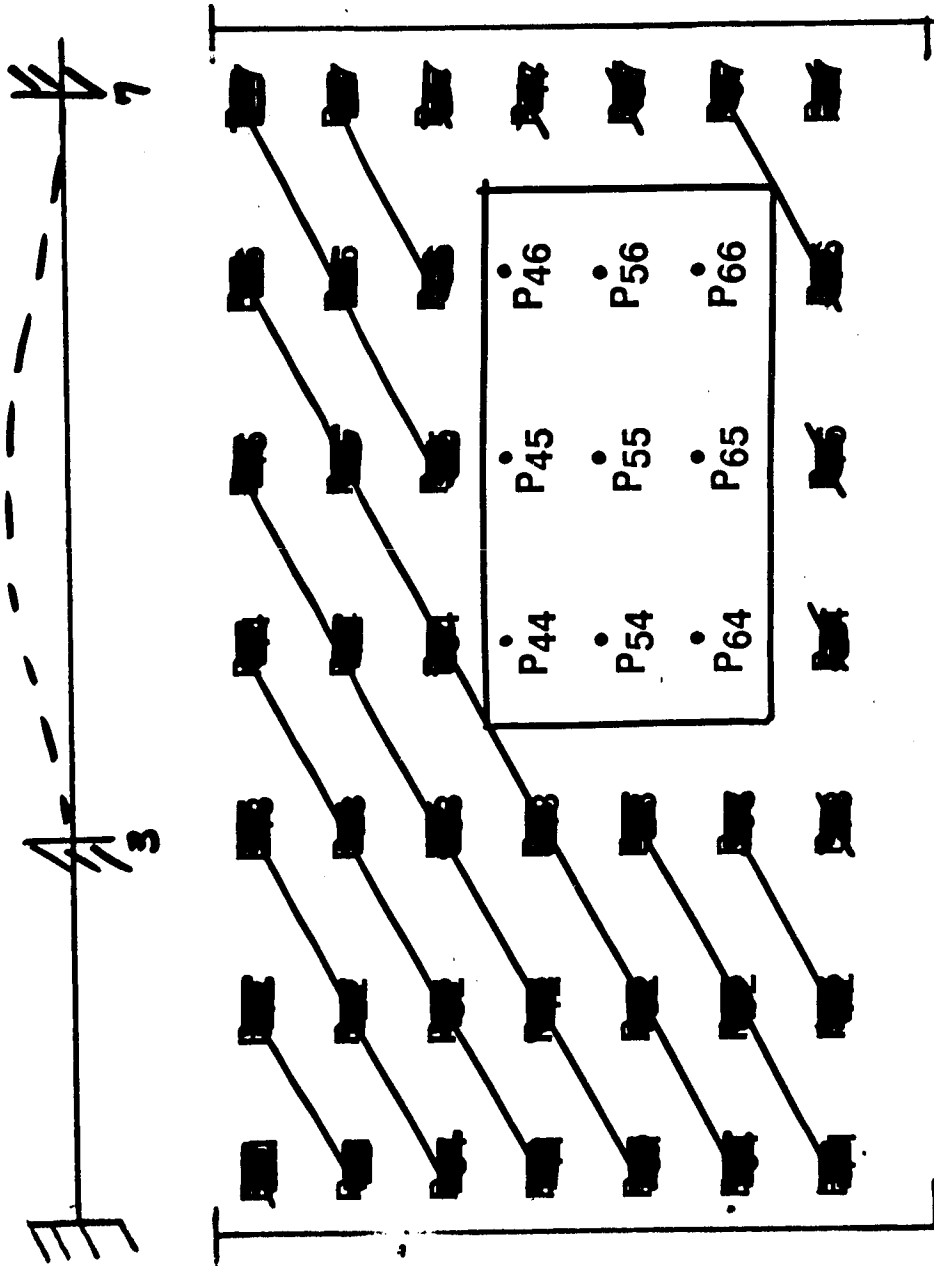
B.C. = -1



JPL

CONTINUOUS TYPE STRUCTURE

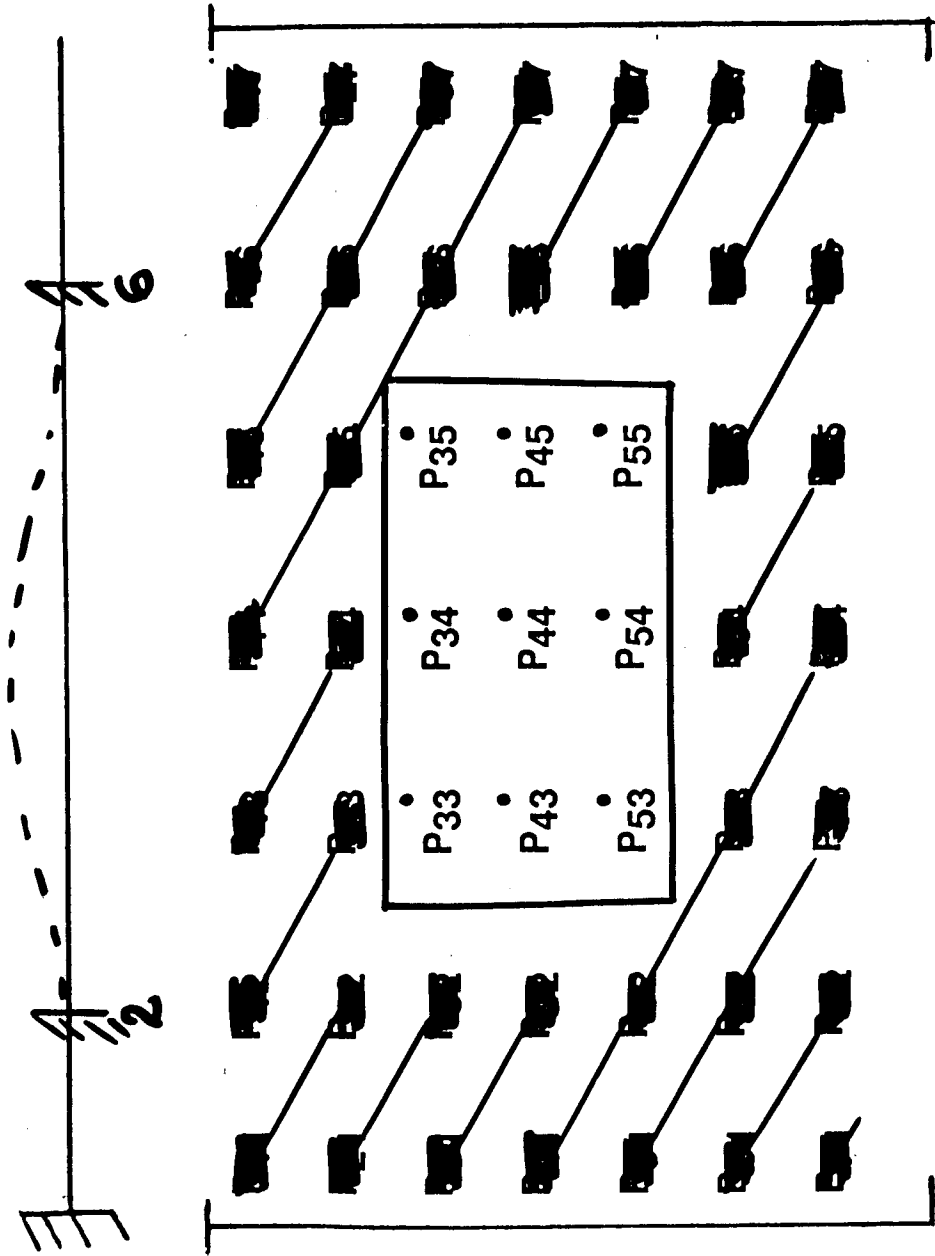
B.C. = - 2



JPL

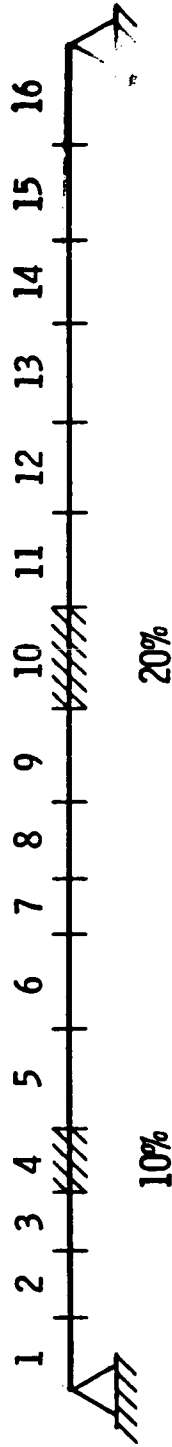
CONTINUOUS TYPE STRUCTURE

B.C. = -3



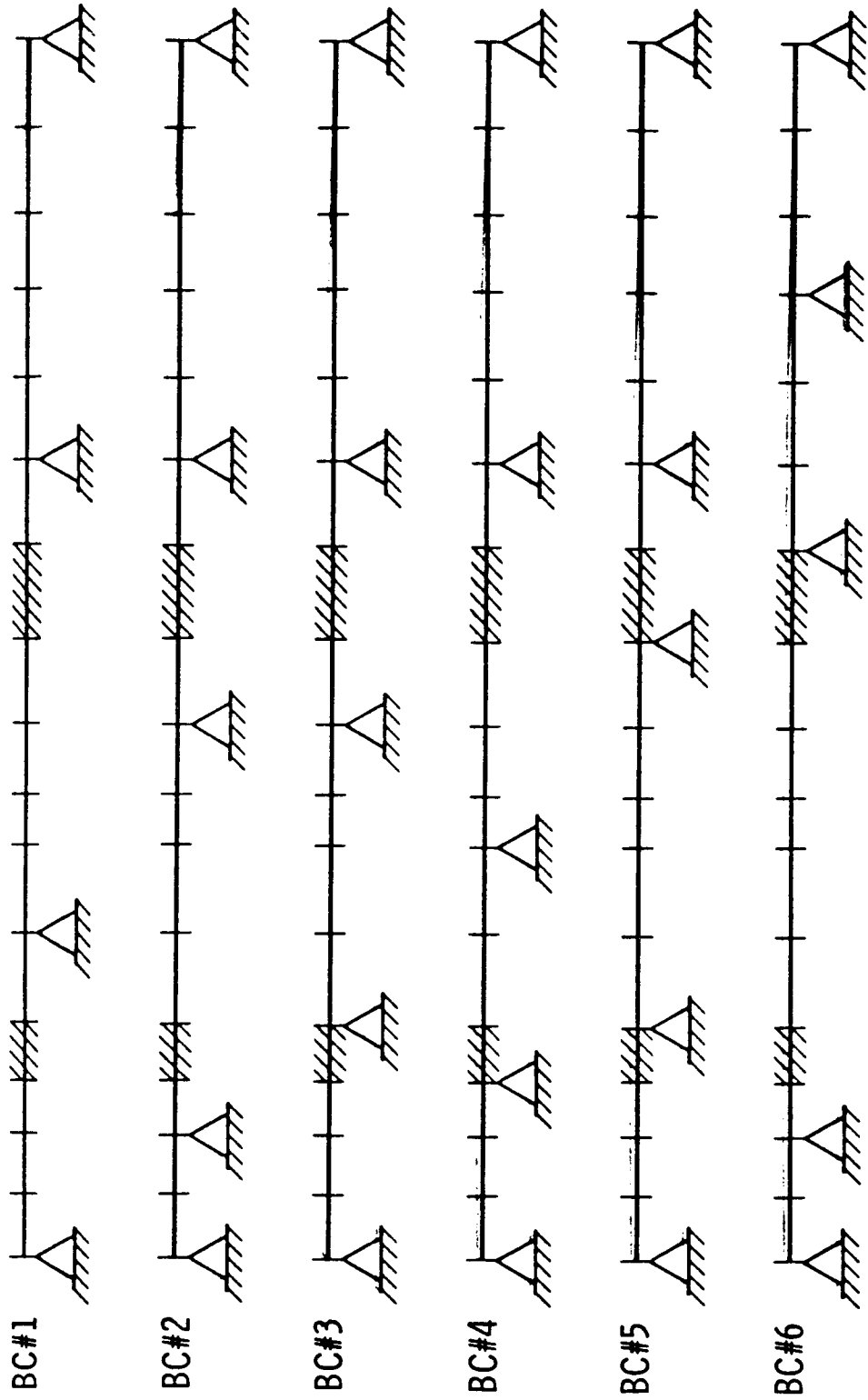
JPL SIMULATED TEST CONFIGURATION

CURRENT APPROACH



JPL

MBCT TEST CONFIGURATIONS



RESULTS OF ESTIMATED PARAMETERS, ITERATIONS 1 AND 2
 ΔI_4 AND ΔI_{10} (THEORETICAL VALUES, $(\Delta I_4 = 0.00834, \Delta I_{10} = 0.01667)$)

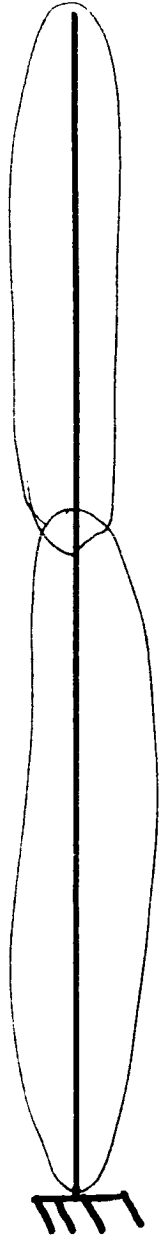
CASE	ITERATION 1	ITERATION 2	CONFIGURATION
a ΔI_4	0.005884	0.008121	CONVENTIONAL MODAL TEST,
	70%	97.38%	10 FREQUENCIES TOTAL
ΔI_{10}	0.015499	0.016722	100.31%
	93%	100.31%	10 FREQUENCIES TOTAL
b ΔI_4	0.007084	0.008330	MBCT CONFIGURATION 1-2,
	85%	99.88%	10 FREQUENCIES TOTAL
ΔI_{10}	0.015291	0.016640	99.82%
	92%	99.82%	10 FREQUENCIES TOTAL
c ΔI_4	0.007849	0.008339	MBCT CONFIGURATION 1-2,
	94%	99.99%	8 FREQUENCIES TOTAL
ΔI_{10}	0.014891	0.016636	99.80%
	89%	99.80%	8 FREQUENCIES TOTAL
d ΔI_4	0.007716	0.008338	MBCT CONFIGURATION 1-2,
	93%	99.98%	6 FREQUENCIES TOTAL
ΔI_{10}	0.014683	0.016630	99.76%
	88%	99.76%	6 FREQUENCIES TOTAL
e ΔI_4	0.007544	0.008336	MBCT CONFIGURATION 1-2,
	91%	99.95%	4 FREQUENCIES TOTAL
ΔI_{10}	0.014360	0.016625	99.73%
	86%	99.73%	4 FREQUENCIES TOTAL

JPL

THE MOMENT OF INERTIA OF EVERY ELEMENT OF THE SIMPLY SUPPORTED BEAM

ELEMENT NO.	USED IN THEORETICAL MODELLING I	REAL I	DIFF %	IDENTIFIED I BY MBCT METHOD (CONFIGURATIONS x MODES)					
				12 x 3	12 x 2	12 x 6	12 x 10	5 x 4	6 x 3
1	.08333	.08333	0	.08286	.08300	.08389	.08339	.08328	.08302
2	.08333	.08750	5	.08767	.08741	.08729	.08766	.08753	.08757
3	.08333	.09166	10	.09162	.09187	.09149	.09128	.09163	.09167
4	.08333	.08750	5	.08747	.08736	.08743	.08779	.08747	.08744
5	.08333	.08333	0	.08329	.08336	.08342	.08320	.08333	.08330
6	.08333	.07916	-5	.07915	.07910	.07911	.07971	.07916	.07917
7	.08333	.04167	-50	.04168	.04169	.04162	.04149	.04167	.04167
8	.08333	.08750	5	.08747	.08737	.08767	.08731	.08751	.08760
9	.08333	.12500	50	.12505	.12530	.12495	.12595	.12501	.12483
10	.08333	.07916	-5	.07910	.07911	.07933	.07900	.07913	.07919
11	.08333	.08750	5	.08755	.08752	.08754	.08696	.08751	.08745
12	.08333	.07916	-5	.07910	.07912	.07840	.08084	.07917	.07916
13	.08333	.08750	5	.08719	.08738	.08831	.08069	.08753	.08761
14	.08333	.15000	80	.14861	.14973	.15237	.16862	.15009	.15006
15	.08333	.07916	-5	.08132	.08058	.08058	.08225	.07900	.07799
16	.08333	.08333	0	.07608	.07626	.07909	.07331	.08369	.08969

LINKED SUBSYSTEMS



P11	P12	P13	P14	P15	P16	P17
P21	P22	P23	P24	P25	P26	P27
P31	P32	P33	P34	P35	P36	P37
P41	P42	P43	P44	P45	P46	P47
P51	P52	P53	P54	P55	P56	P57
P61	P62	P63	P64	P65	P66	P67
P71	P72	P73	P74	P75	P76	P77

MODAL SYNTHESIS

$$\begin{aligned}
 \{u\}^i &= q_R^i \{\phi\}_R^i + q_C^i \{\phi\}_C^i + q_N^i \{\phi\}_N^i + q_A^i \{\phi\}_A^i \\
 &+ q_Q^i \{\phi\}_Q^i + q_I^i \{\phi\}_I^i + q_{RE}^i \{\phi\}_{RE}^i + \dots + q_U^i \{\phi\}_U^i
 \end{aligned}$$

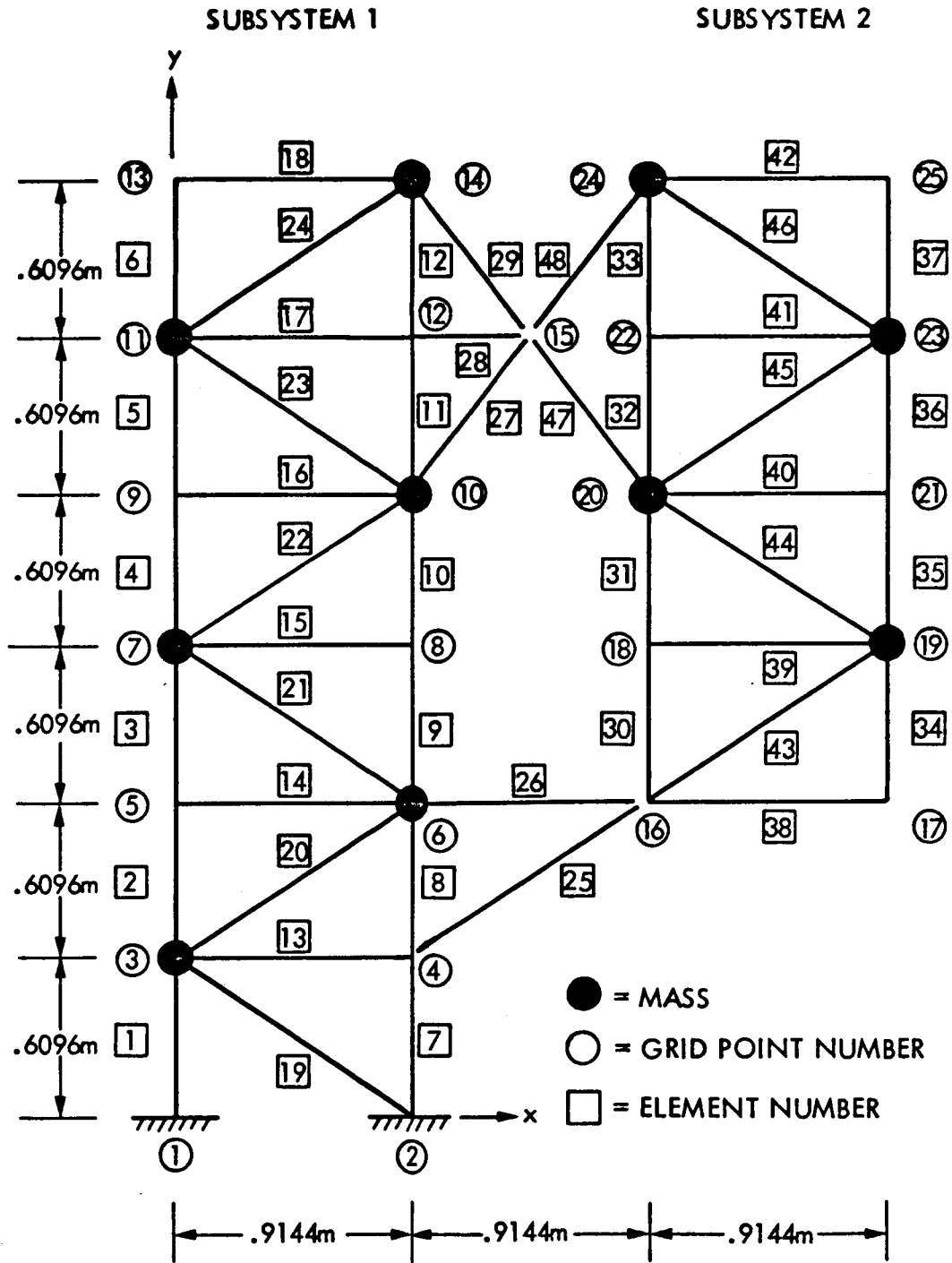


FIGURE 3. SAMPLE PROBLEM TOTAL SYSTEM

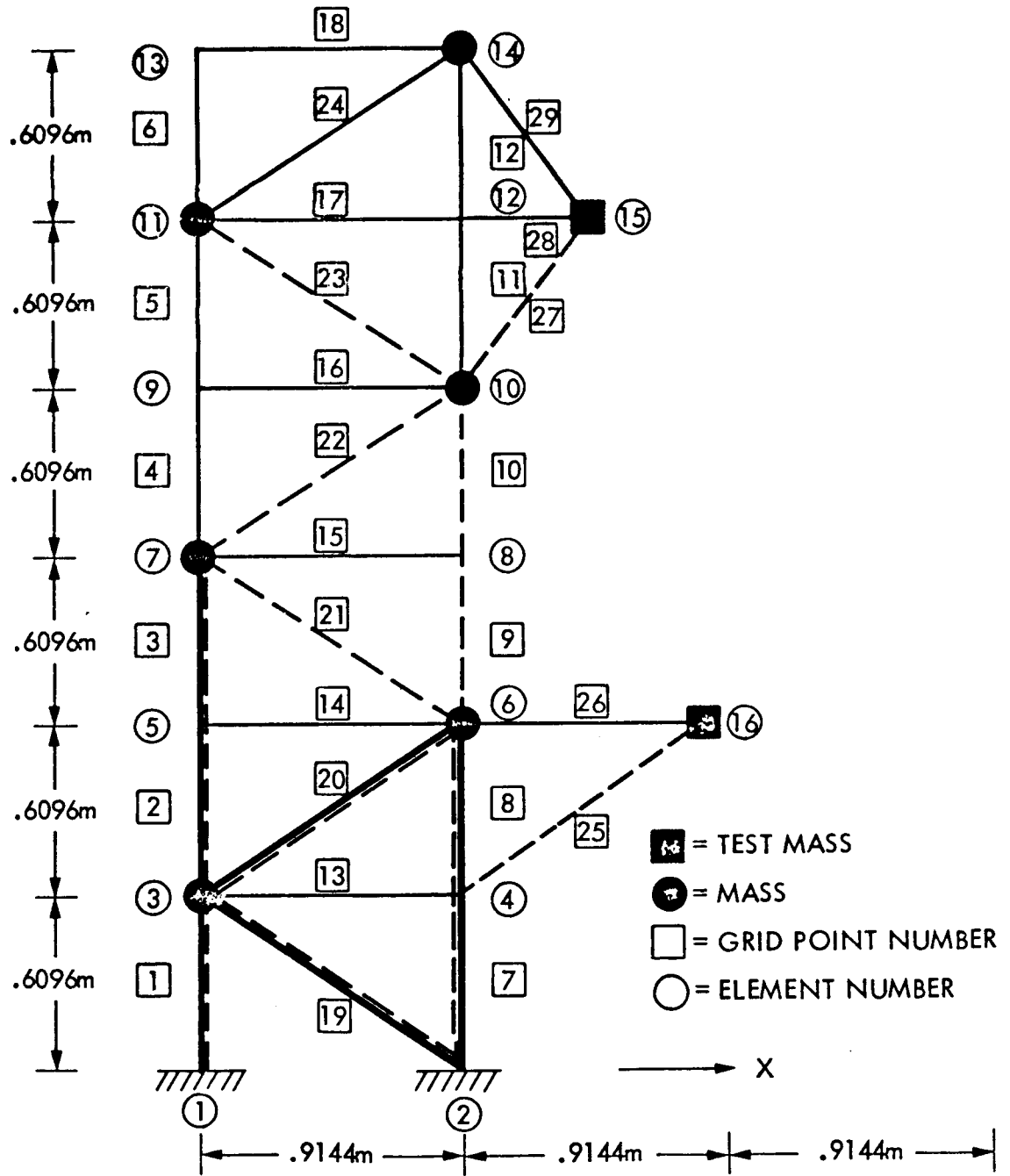


FIGURE 4. SUBSYSTEM 1

LOADS CONDITION

- MODAL TEST "TEST MASS" AT ⑮
- MODAL TEST "TEST MASS" AT ⑯
- FORCE AT ⑮, X & Y-DIR.
- FORCE AT ⑯, X & Y-DIR.
- FORCE AT ⑩, X & Y-DIR.

JPL **LOAD CONDITION vs SE IN MEMBERS**
 >10% SE

MEMBERS /	LOAD	1	2	3	4	5
COND	COND					
21, 22, 23	→					X
9, 10		X		X		X
25			X		X	
27				X		

JPL

COMPARISON

MODE NO.	CORRECT (Hz)	ESTIMATED (Hz)
1	4.044	4.041
2	15.209	15.015
3	27.054	26.814
4	30.077	30.097
5	35.832	36.222

MEMBER 25 & 27 - ERROR BY 100%



SUMMARY

- **Not Rely on Ground Test Which Simulates Space Conditions.**
- **Integrated - Test/Analysis**
- **Developing Concepts**
- **Validate on Laboratory and Flight Experiments.**

April 22, 1986 (Concurrent Sessions on Structures and Control)

Control Session 2A - Leonard Meirovitch, Chairman

Optimum Mix of Passive and Active Control for Space Structures	L. Rogers, W-P AFB
1-CAT: A MIMO Design Methodology	J. R. Mitchell, J. C. Lucas, Control Dynamics
Inter-Stable Control Systems	G. von Pragenau, MSFC
Status Report and Preliminary Results of the <u>S</u> pacecraft <u>C</u> ontrol <u>L</u> aboratory	J. P. Williams, LaRC

Control Session 2B - J. L. Junkins, Chairman

Flexible Spacecraft Control Simulation	J. Bossi, Boeing
Improving Stability Margins in Discrete-Time LQG Controllers	B. T. Oranc and C. L. Phillips, Auburn
An Overview of Research Conducted by the Spacecraft Control Branch on the NASA LaRC Grid	R. C. Montgomery, LaRC
Space Station Structural/Control Interaction (Payload Pointing and Micro-G)	C. R. Larson Rockwell/SD