N87-22713

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VERIFICATION OF FLEXIBLE STRUCTURES BY GROUND TEST

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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

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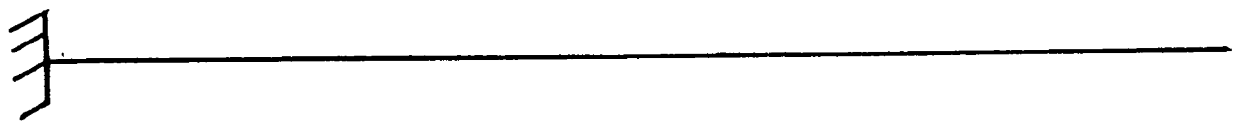
OBJECTIVE

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

- Present Concepts for Two Types
  - Continuous Type
  - Linded Subsystems

CONTINUOUS TYPE STRUCTURE

B.C. = -



$$
\begin{bmatrix}
P_{11} & P_{12} & P_{13} & P_{14} & P_{15} & P_{16} & P_{17} \\
P_{21} & P_{22} & P_{23} & P_{24} & P_{25} & P_{26} & P_{27} \\
P_{31} & P_{32} & P_{33} & P_{34} & P_{35} & P_{36} & P_{37} \\
P_{41} & P_{42} & P_{43} & P_{44} & P_{45} & P_{46} & P_{47} \\
P_{51} & P_{52} & P_{53} & P_{54} & P_{55} & P_{56} & P_{57} \\
P_{61} & P_{62} & P_{63} & P_{64} & P_{65} & P_{66} & P_{67} \\
P_{71} & P_{72} & P_{73} & P_{74} & P_{75} & P_{76} & P_{77}
\end{bmatrix}
$$

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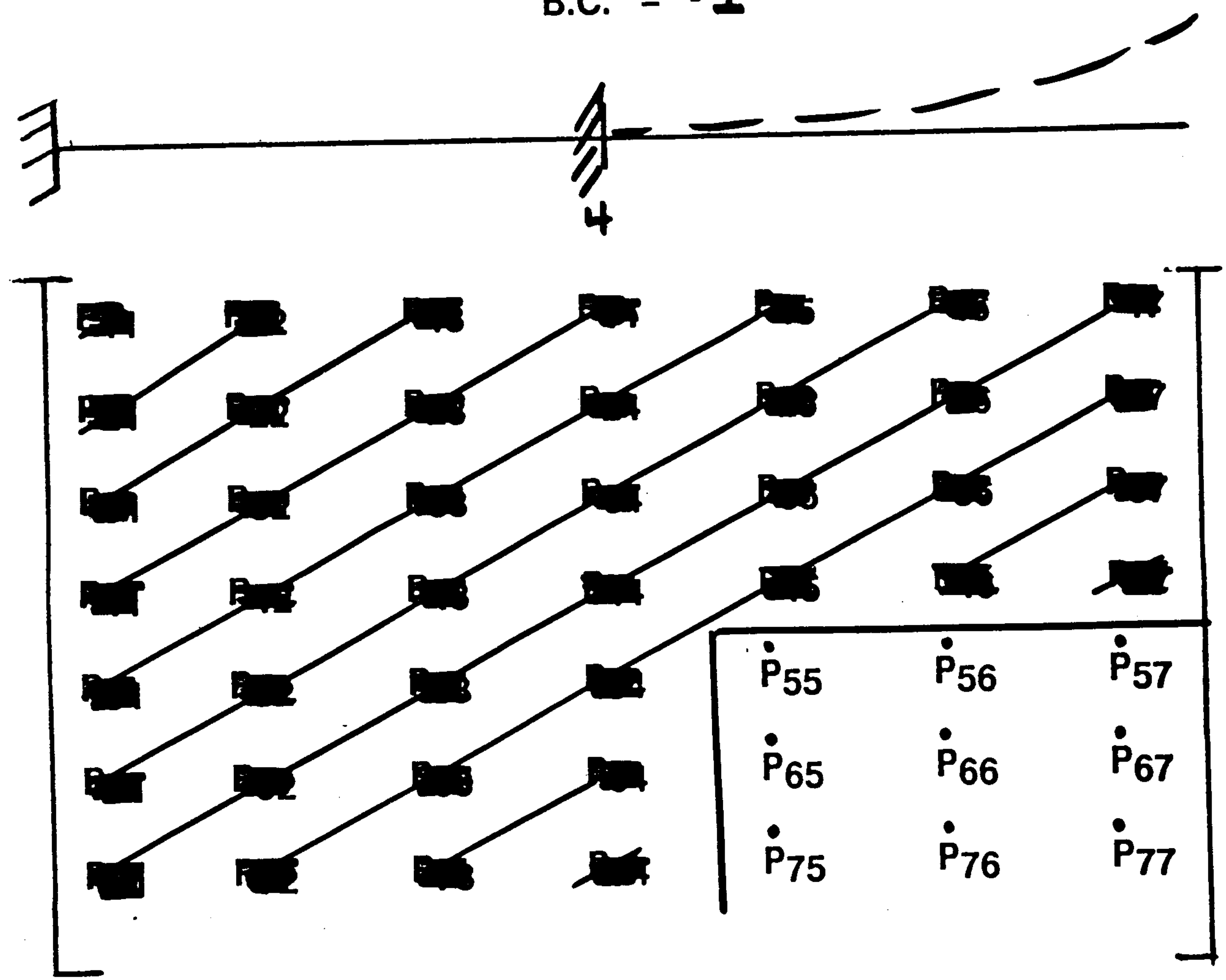
CONTINUOUS TYPE STRUCTURE

B.C. = -1



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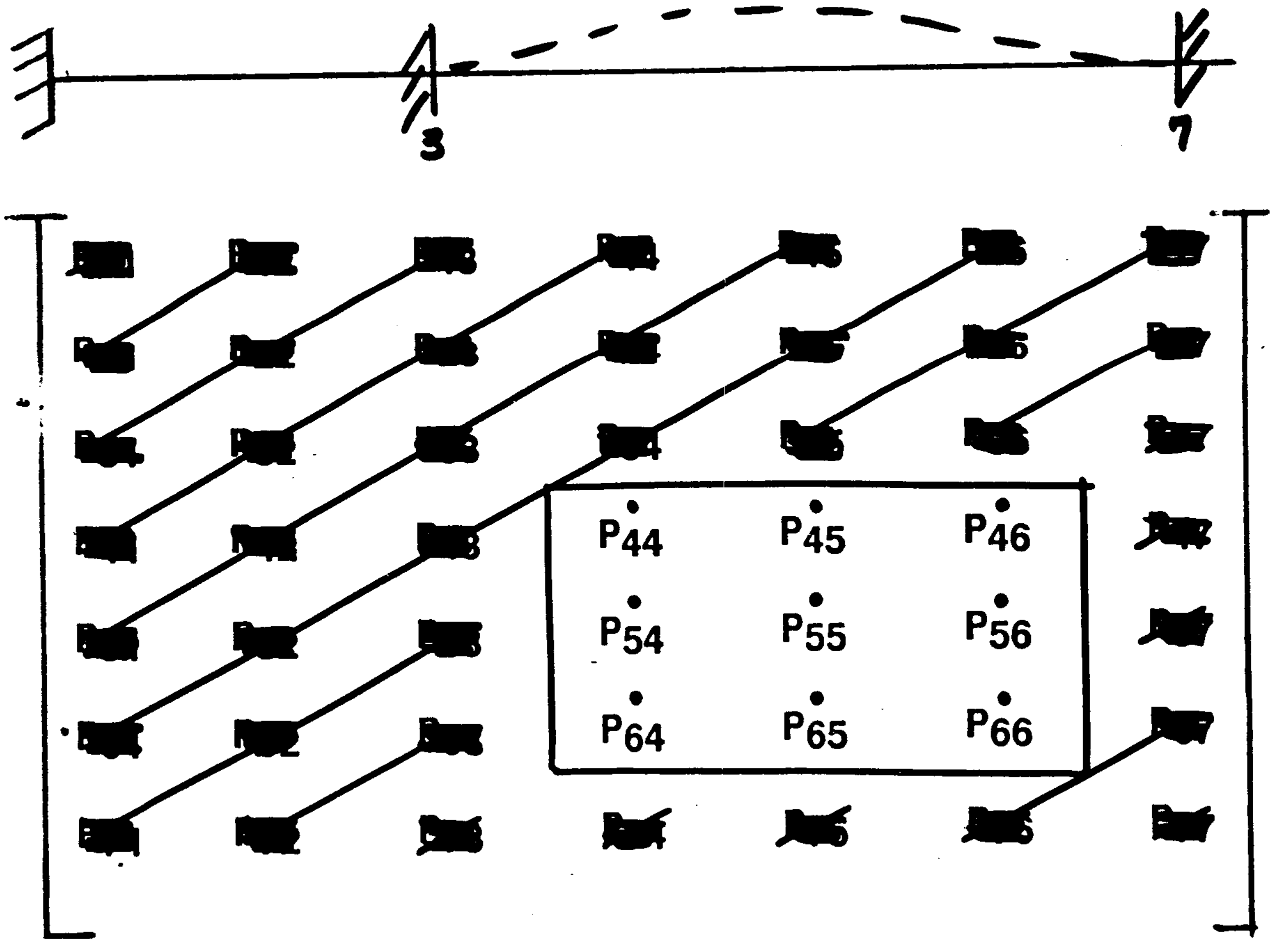
CONTINUOUS TYPE STRUCTURE

B.C. = - 2



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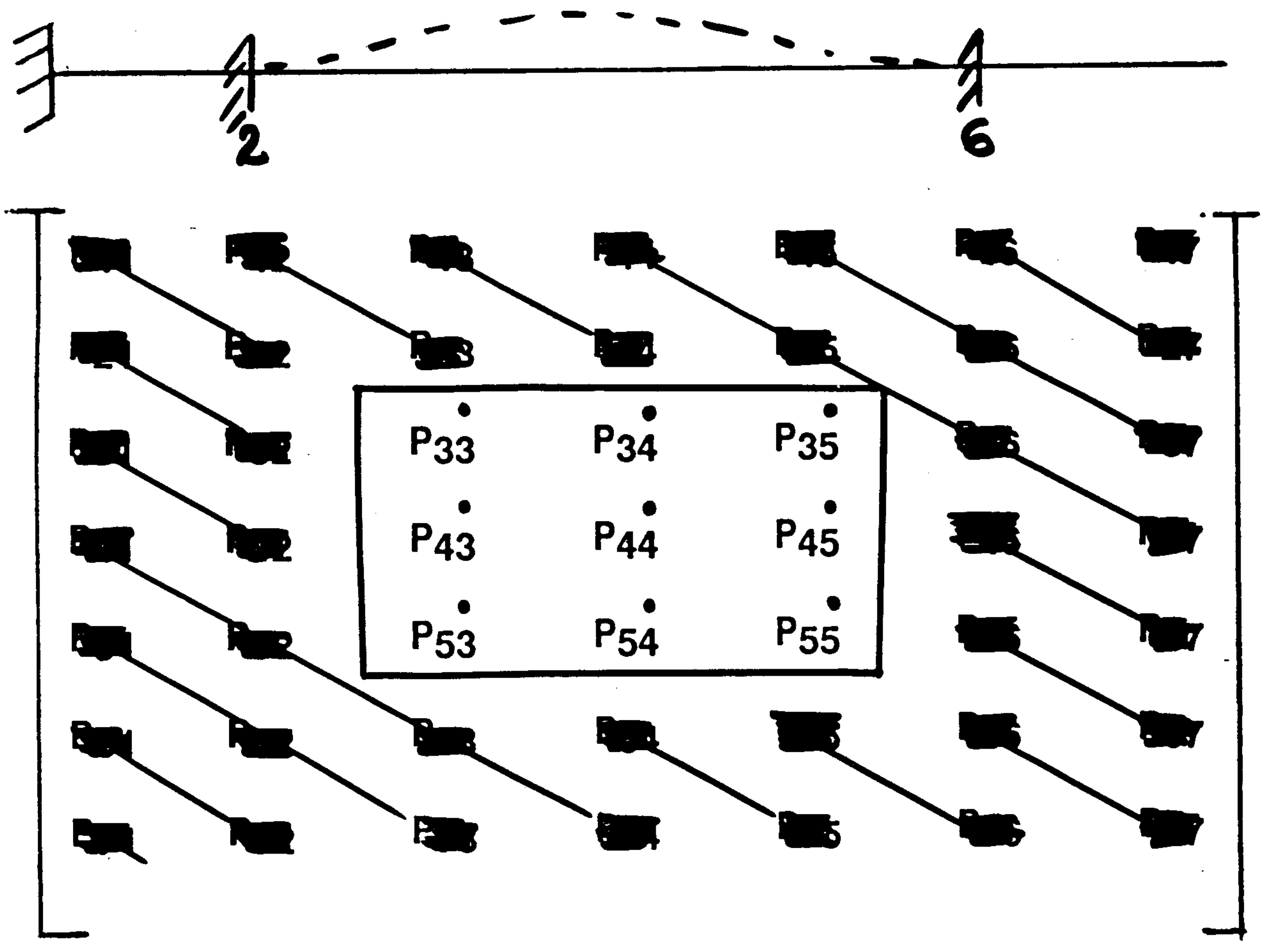
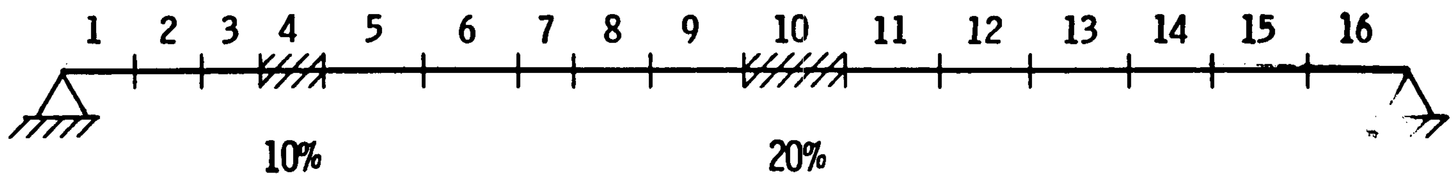
CONTINUOUS TYPE STRUCTURE

B.C. = -3

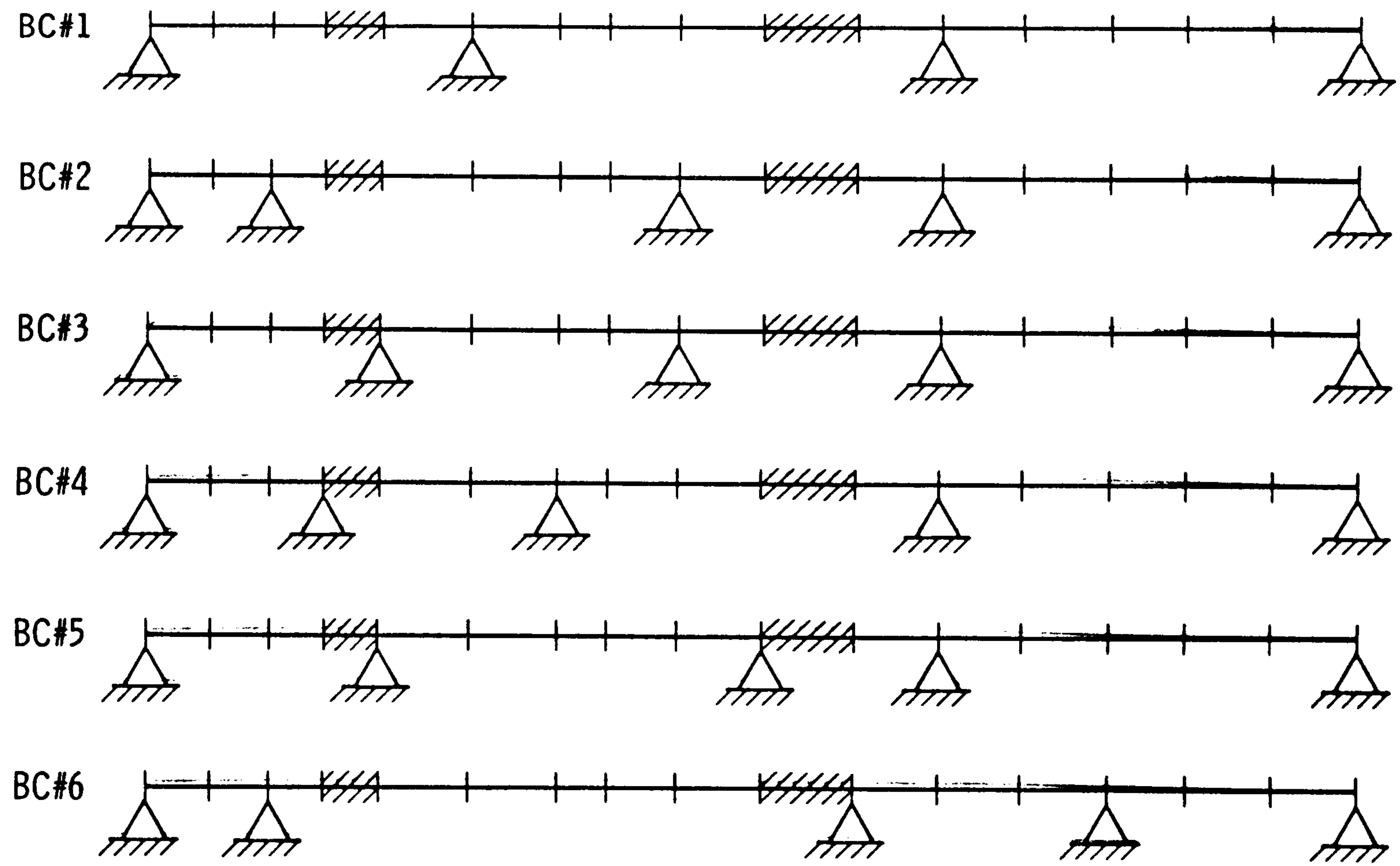


SIMULATED TEST CONFIGURATION

CURRENT APPROACH



MBCT TEST CONFIGURATIONS



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

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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

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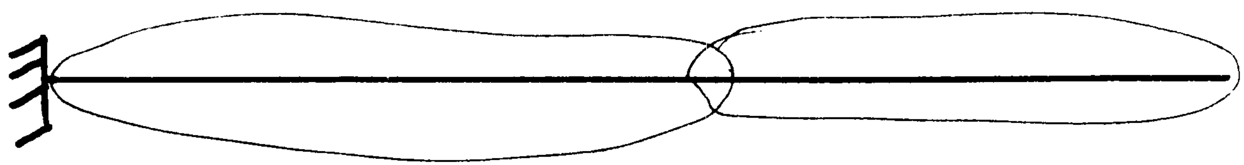
LINKED SUBSYSTEMS



$$\begin{bmatrix} P_{11} & P_{12} & P_{13} & P_{14} & P_{15} & P_{16} & P_{17} \\ P_{21} & P_{22} & P_{23} & P_{24} & P_{25} & P_{26} & P_{27} \\ P_{31} & P_{32} & P_{33} & P_{34} & P_{35} & P_{36} & P_{37} \\ P_{41} & P_{42} & P_{43} & P_{44} & P_{45} & P_{46} & P_{47} \\ P_{51} & P_{52} & P_{53} & P_{54} & P_{55} & P_{56} & P_{57} \\ P_{61} & P_{62} & P_{63} & P_{64} & P_{65} & P_{66} & P_{67} \\ P_{71} & P_{72} & P_{73} & P_{74} & P_{75} & P_{76} & P_{77} \end{bmatrix}$$

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MODAL SYNTHESIS

$$\{u\}^i = q_R^i\{\phi\}_R^i + q_C^i\{\phi\}_C^i + q_N^i\{\phi\}_N^i + q_A^i\{\phi\}_A^i$$

$$+ q_Q^i\{\phi\}_Q^i + q_I\{\phi\}_I^i + q_{RE}\{\phi\}_{RE}^i + \cdots + q_u^i\{\phi\}_u^i$$

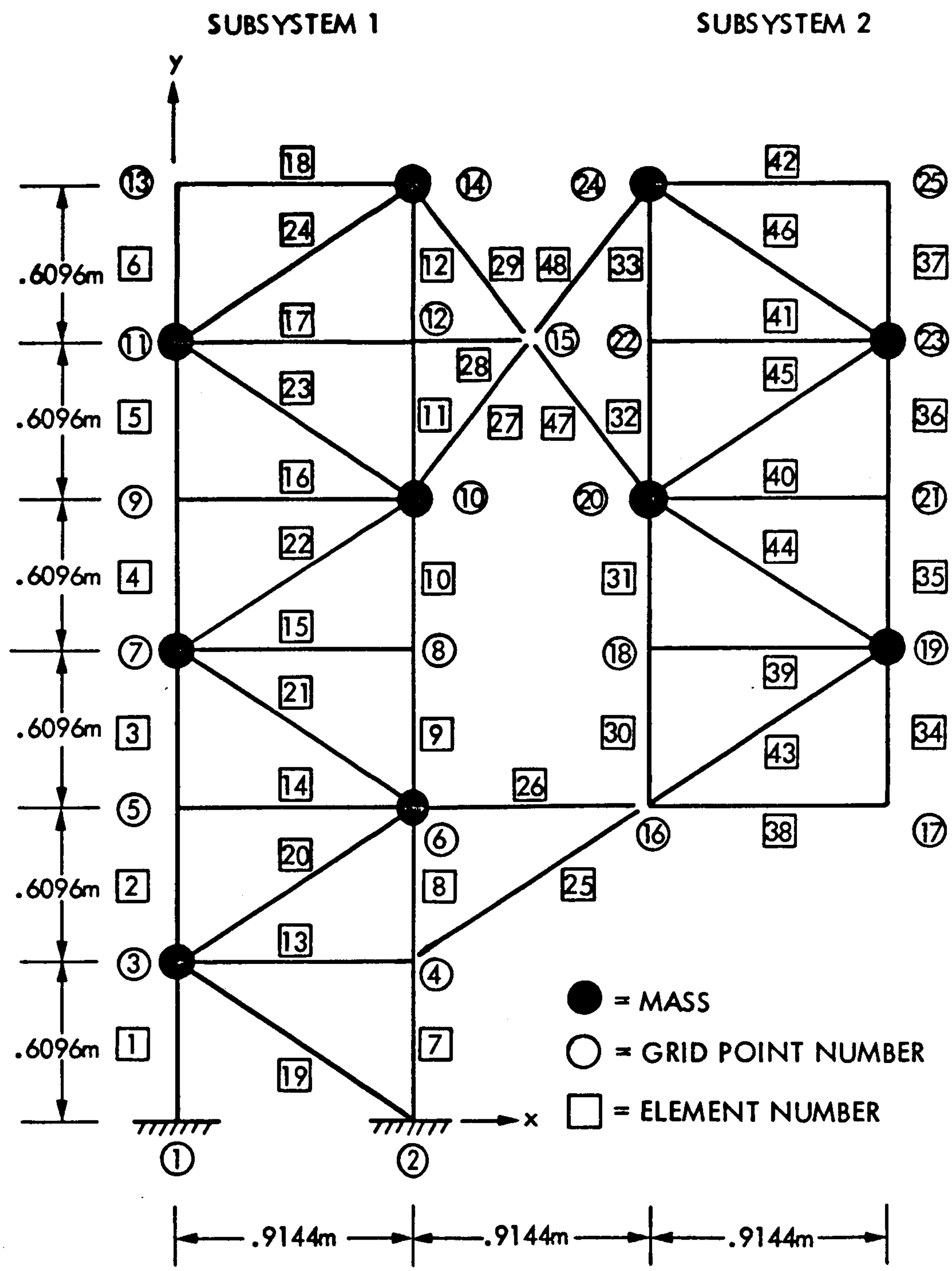

FIGURE 3. SAMPLE PROBLEM TOTAL SYSTEM

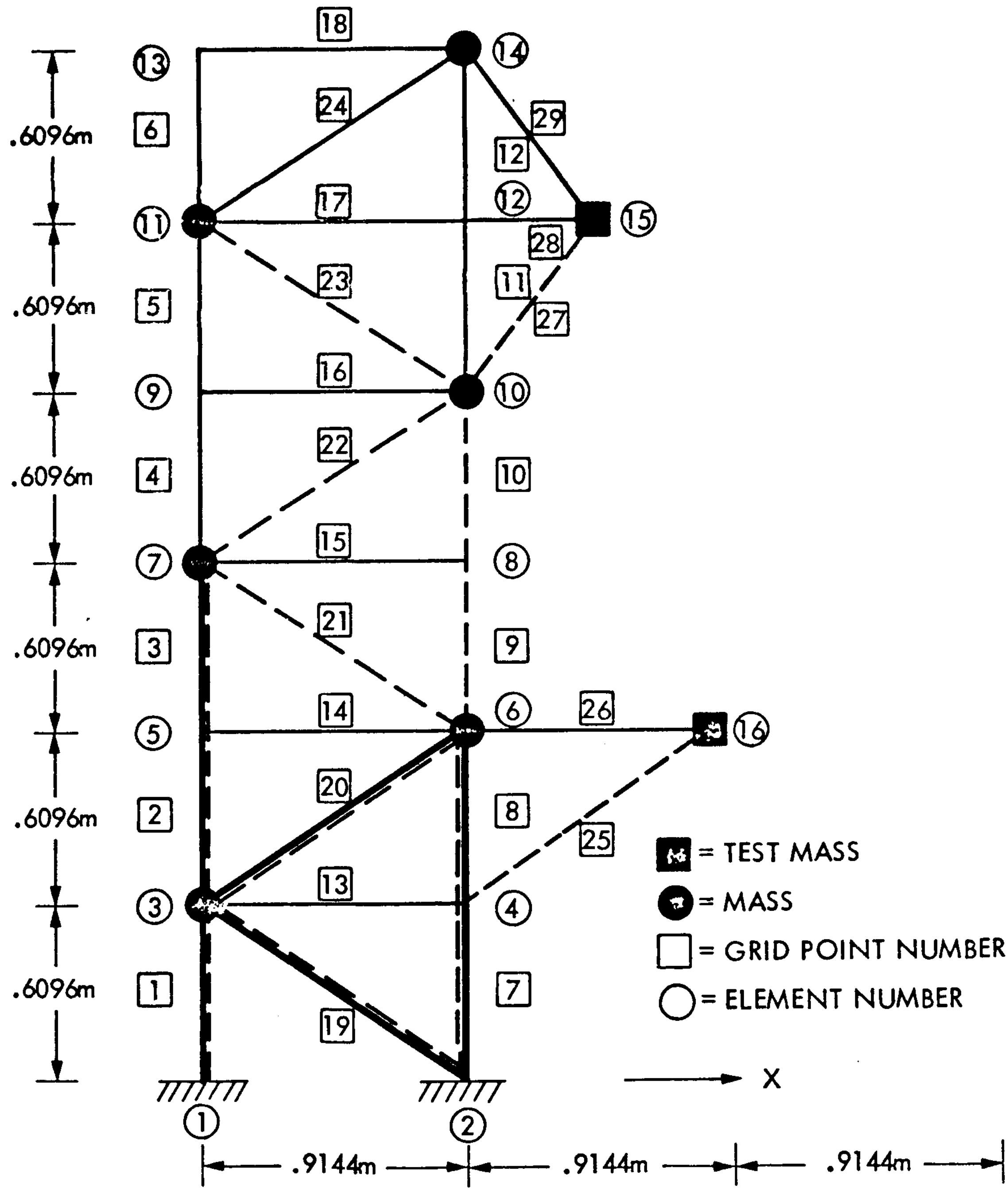

FIGURE 4. SUBSYSTEM 1

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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.

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LOAD CONDITION vs SE IN MEMBERS

>10% SE

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

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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%

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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 Spacecraft Control Laboratory	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