

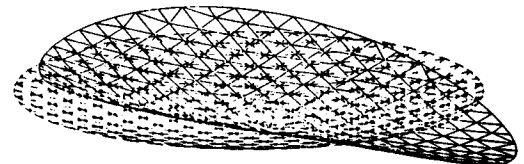
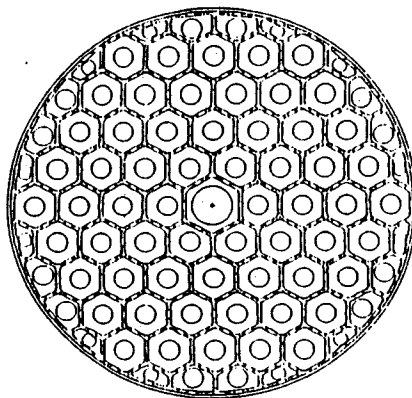
COLUMBUS PROJECT

MIRROR BLANK 1.8 DIAM F1

FINITE ELEMENT ANALYSIS

NATURAL FREQUENCIES

REPORT N.3
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MILANO, 1987, MARCH 30TH



1. INTRODUCTION

Before starting the dynamic analysis of the 1.8 m mirror, we have performed some tests to evaluate the precision of the SAP program and to obtain some informations on the possibility of representing the mirror's behaviour using simplified E.F. models.

These models have been obtained as follows:

- 1) We have found the the equivalence between the honeycomb structure and a solid plate structure. The plate's thickness is such as to realize the same flexural properties of the honeycomb structure.
- 2) We have prepared two plate models having the same dimensions, shape and constraints of the real mirror. The first plate is plane and has constant thickness, the second plate is curved (like the mirror surface) and has varying thickness to represent the difference of flexural properties, according to the mirror's height variation.
- 3) We have performed a static analysis on the plate models, loading the plates with forces equal to the mirror's dead weight.

In the next table we give the results. You must notice that the displacements are very similar in all the cases. The precision can be improved if you pass from the plane-plate model to the curved-plate model, having the same mirror's bending radius. These results are also very similar to the theoretical values.

maximum displacement [mm]				
CONSTRAINTS	HONEYCOMB	THIN PLATE		
	F.E. REAL MIRROR	F.E. PLANE-PLATE	F.E. CURVED-PLATE	THEORY
Supports on the edge	0.00228	0.00250	0.00233	0.00244

*** OBSERVATION: the theoretical value has been calculated for a circular plate of constant thickness and without the circular hole in the centre.

The results of this static analysis show that the equivalence criteria, which have been assumed to represent the honeycomb structure with a solid plate structure, are correct and that we can well represent the mirror's static behaviour with a simplified plate model (in our hypotheses of load and constraints).

After the static analysis we have tried to represent the dynamic behaviour using the same simplified E.F. models. In the next tables we give the first fundamental frequency for each case:

First frequency [Hz]				
CONSTRAINTS	HONEYCOMB	THIN PLATE		
	F.E. REAL MIRROR	F.E. PLANE-PLATE	F.E. CURVED-PLATE	THEORY
Supports on the edge	277.7	394.0	415.9	415.1

The dynamic analysis shows a big difference between the real mirror's structure and the plate structure, so that we can't represent the dynamic behaviour using simplified E.F. models. Nevertheless, you must notice the precision of the SAP program in finding the frequency of the plate: the theoretical value and the calculated value are very similar.

2. MODEL WITH REAL THICKNESS

The dynamic analysis of the mirror has been performed with the following hypotheses:

- 1) The mirror has been constrained with three supports, positioned on the nodes 491-493-495 (radial distance from the centre =574.3 mm), so that it is an isostatic structure. Supports are symmetrically located respect to the z-axis, normal to the mirror's surface, and each has been modelled using two boundary elements as shown in figure 1. One gives constraint in the vertical direction z, the other gives constraint in the plane of the mirror's surface.
- 2) The mass density of the mirror has been automatically evaluated by the program, beginning from the specific weight value (=21386 N/m³) and the gravity acceleration (=9.81 m/s²).

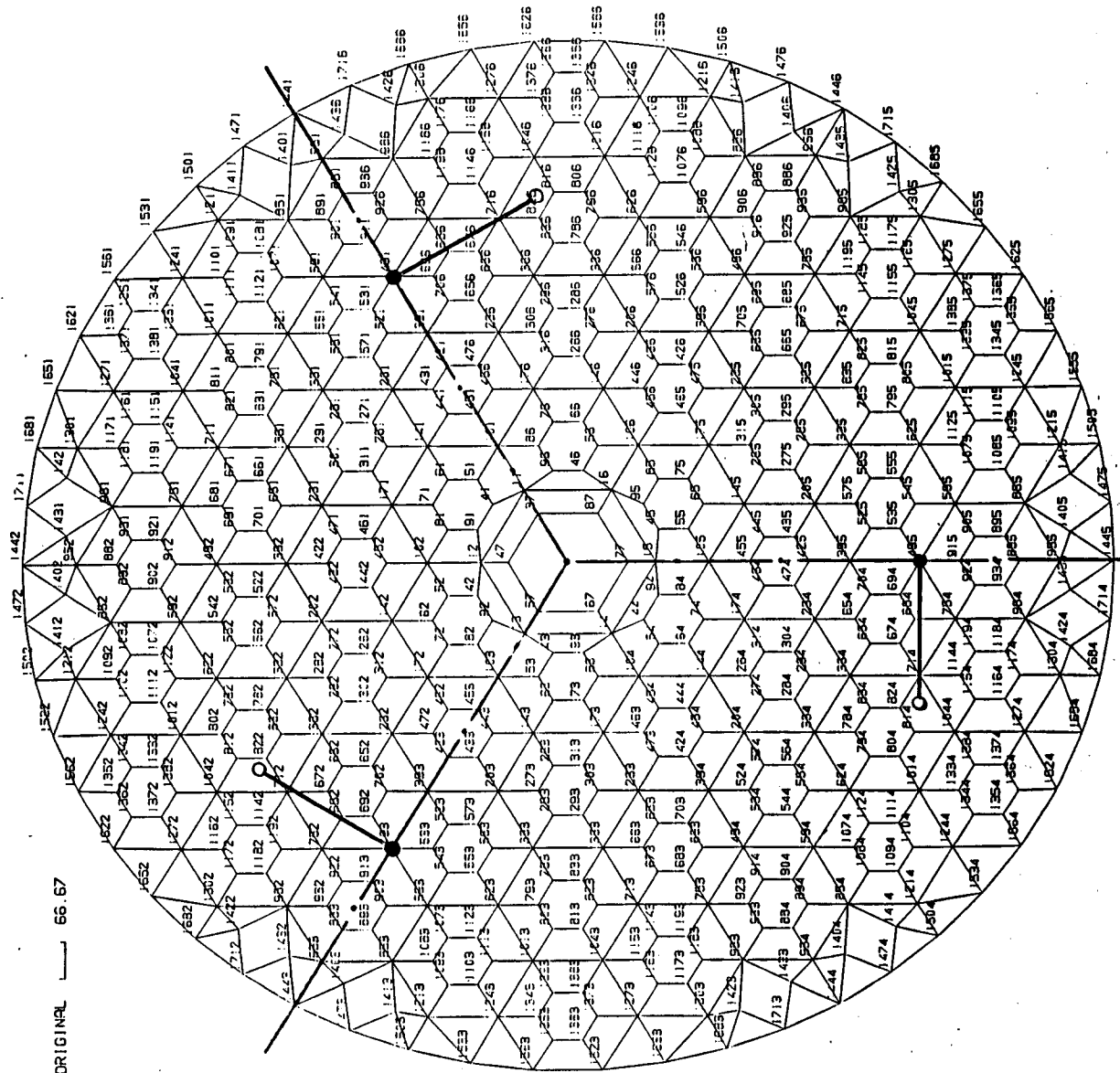
We have studied the first five fundamental frequencies. In the following table we give the results:

MODE NUMBER	FREQUENCY (rad/sec)	FREQUENCY (cycles/sec)	PERIOD (sec)
1	1153	183.4	0.005452
2	1153	183.5	0.005450
3	1921	305.8	0.003270
4	2015	320.7	0.003118
5	2016	320.6	0.003117

Figures 2-6 represent the mirror's mode shapes.

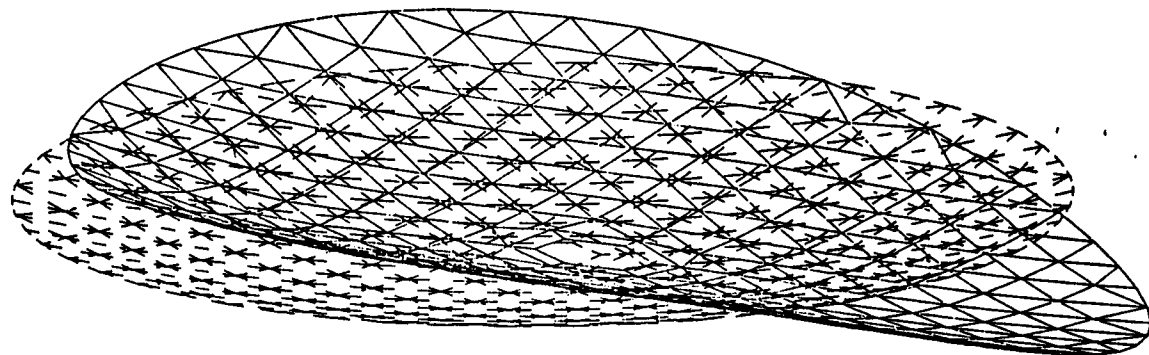
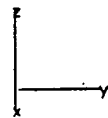


CONSTRAINTS IN Z DIRECTION
TRUSS FOR CONSTRAINTS
IN X-Y PLANE



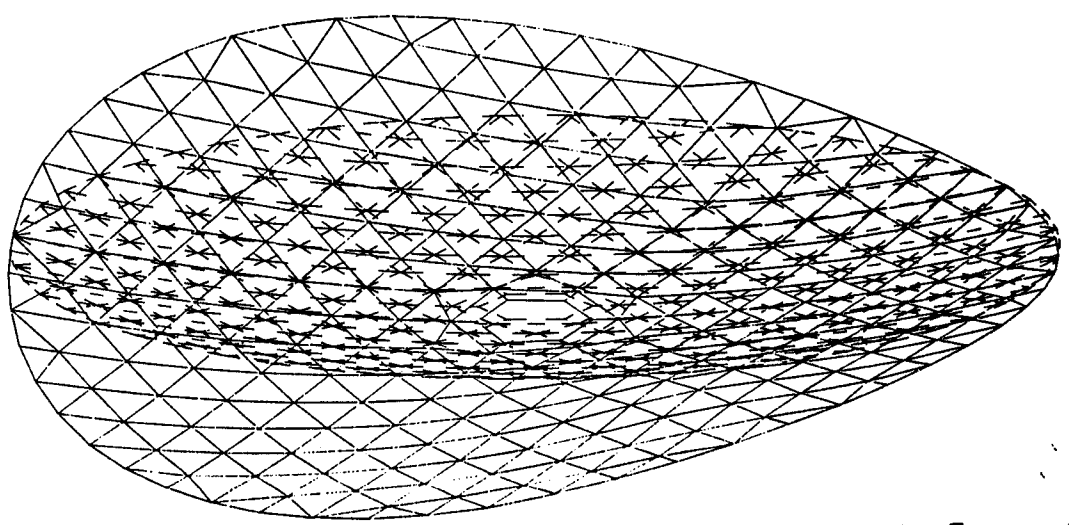
[FIGURE 1]

BCV progettl - MIRROR BLANK 1.8 m. F1 - NATURAL FREQUENCIES
mode 1 frequency= 183.43
7.11.46 10/ 1/1987
taxis= 3 alpha= 15.00 beta= 0.
deflection scale factor= 0.3481



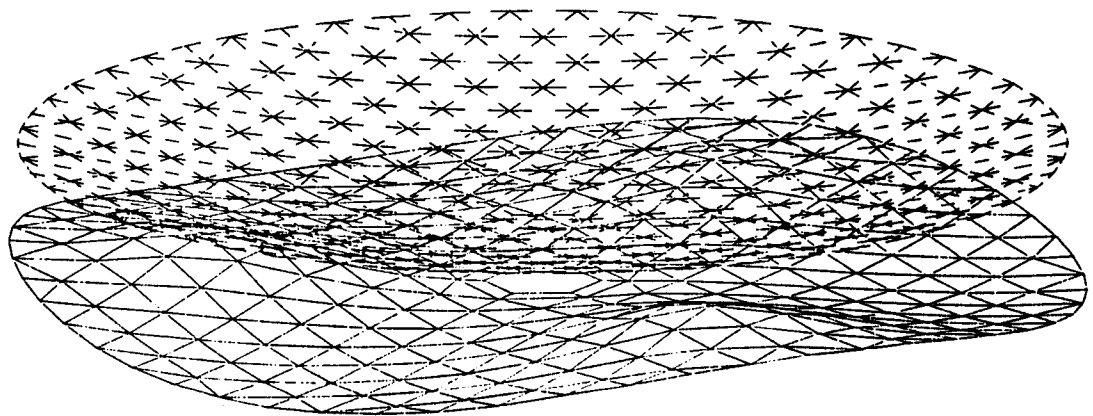
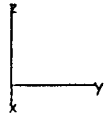
[FIG. 2]

BCV progetto1 - MIRROR BLANK 1.8 m. F1 - NATURAL FREQUENCIES
mode 2 frequency= 183.48
7.11.46 10/ 1/1987
taxts= 3 alpha= 15.00 beta= 0.
deflection scale factor= 0.3934



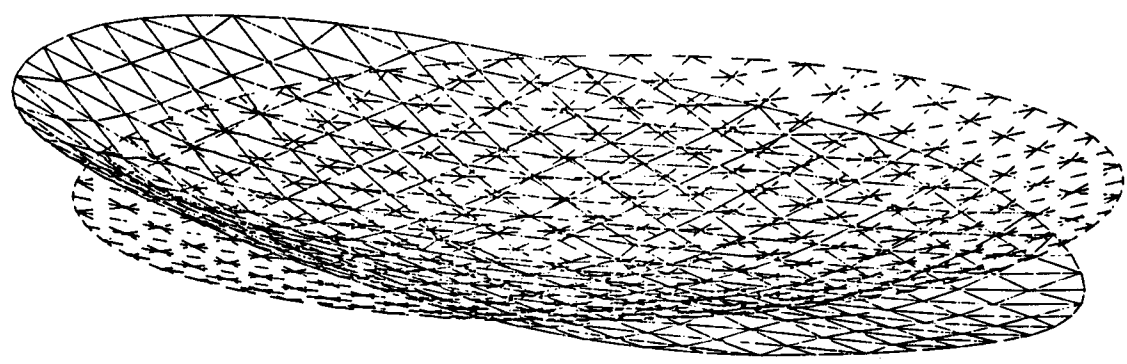
[FIG. 3]

DCV progettl - MIRROR BLANK 1.8 m. F1 - NATURAL FREQUENCIES
mode 3 frequency= 305.79
7.11.46 10/ 1/1987
taxts= 3 alpha= 15.00 beta= 0.
deflection scale factor= 0.5412



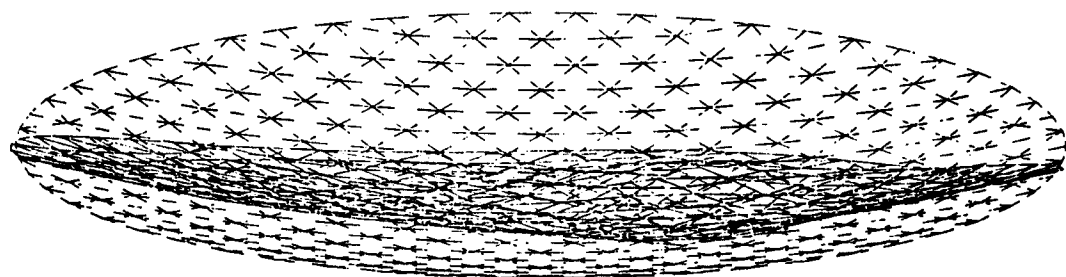
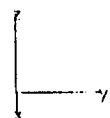
[FIG. 4]

BCV progetto - MIRROR BLANK 1.8 m. F1 - NATURAL FREQUENCIES
mode 4 frequency = 320.73
7.11e46 10/ 1/1387
Laxls = 5 alpha = 15.00 beta = 0.
deflection scale factor = 0.4586



[FIG. 5]

BCV progetto - MIRROR BLANK 1.8 m F1 - NATURAL FREQUENCIES
mode 5 frequency= 320.82
7.11.46 10/ 1/1987
Casts= 3 alpha= 15.00 beta= 0.
deflection scale factor= 0.3295



[FIG. 6]